

Knowledge Elicitation, Semantics and Inference.

A.G.T. Martin Pittock



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ABSTRACT

Knowledge elicitation, semantics and inference.

The elicitation of knowledge from experts for the purpose of building expert systems has been automated with varying degrees of sophistication. The extent to which a human being or a machine can comprehend verbalised expertise depends in part on knowledge of the basic or non-technical words of the language and the domain-independent inferences that it is possible to make from them concerning the technical words of the discourse.

Lexical entailments have traditionally been characterised in terms of selectional restrictions. These tend to proscribe all metaphorical language from the most abstruse and poetic to the most ubiquitous and prosaic. A principled method of semantic inference and disambiguation is needed.

The Introduction gives an account of the history of the research and its provenance. Chapter 1 surveys existing knowledge elicitation techniques and Chapters 2 and 3 give an account of philosophical and linguistic approaches to the problem of word meaning. Chapters 4 to 7 outline a principled method of lexical inference and disambiguation characterised by the Principles of Prediction and Coercion and Chapter 8 discusses semantic inference in general, from strong uncancellable logical entailments to weak connotative suggestion. Appendix 1 contains the Principles of Prediction and Coercion in a tabular form and Appendix 2 implements these Principles in a program.

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Introduction.

0.1 Preview.

Not everything we read or hear is immediately comprehensible to us. This may be for a number of reasons. Speech can be inaudible or writing illegible. If neither of these is the reason, speech may be disfluent or writing ungrammatical.

However, even when there is no physical or grammatical barrier to our understanding we may still fail to understand. This may be because what is being said or written is meaningless. If this is not the case we fall back on a number of possibilities. People may use words we have never heard before or have forgotten the meaning of. They may use words we know that have a secondary meaning we don't know or have not applied. Even if the meaning is transparent to us we may say we don't understand because we cannot see the relevance of what is said to the conversation or situation or we cannot construe the metaphorical or poetic usage.

Despite all these obstacles we are rarely completely baffled. In speech, clues can be picked up from gesture and intonation and, in text, the syntax and semantic province of an unknown word is circumscribed by its neighbours. Words, like people, can be known by the company they keep. The influence of a word's neighbours varies from a strong logical coercion to a weak suggestive connotation. Propinquity is not the sole criterion of neighbourhood. The various semantic influences

that operate in a sentence are related to the logical form of that sentence.

The aim of this work is to characterise a principled method of construing the meaning of unknown or anomalous words and phrases. The motivation of this work is partly theoretical, to furnish a contribution to lexical semantics, and partly practical, to provide a mechanism to assist in automated knowledge acquisition in the field of artificial intelligence.

0.2 History of the research.

The work is a continuation of work done in 1986 and 1987 in Aberdeen as part of an Alvey project. Part of the project was to design a computer program that would accept domain knowledge provided by an expert in that domain and, by way of intelligent questions, elicit more information. A simple program was written where the interface was a graphical one and the only acceptable input was in the form of binary links or two-place predicates in a network diagram, for example, in the input

creampuffs cause spots,

the word "cause" would be matched with the canned response "do they cause anything else?" and so on. The system was written in the language InterLisp-D and there was no parser, logical representation, database and thus no query facility about knowledge entered. The system seemed to have potential on a

limited subset of language but did not work in conjunction with any knowledge representation system, which was a disadvantage. Moreover it could not properly be said to be intelligent nor to embody any linguistic theory of lexical semantics and inference. It seemed that an extended program might serve as a vehicle for a linguistic theory and, at the same time, have potential as a knowledge elicitation system in the field of expert systems.

The Aberdeen implementation was in a dialect of the language Lisp which was useful for string-processing and pattern matching but not so appropriate for knowledge-representation and inference. Since a knowledge acquisition program that doesn't store the knowledge elicited isn't much good, it seemed a better idea to use the language Prolog that is good for handling databases but can also cope with string-processing and parsing.

0.3 Contributions to linguistics and artificial intelligence.

This work is intended to be a contribution to linguistics. Aitchison (Aitchison 1978) identifies two of the central questions of linguistics as 'how does language work?', and 'what do all languages have in common?'. As stated above, our second aim is to assist in automated knowledge acquisition. However this is dependent on our first aim, namely to provide a principle of lexical resolution of anomalous and unknown words and phrases. This may be considered as an, at least partial, answer to the question of how language works. As to the

applicability of such a principle to languages in general, this question is outside the scope of this thesis although it might be noted in passing that the principle is founded on certain metaphysical claims about the ontological classes of words and one might conjecture that these metaphysical foundations are language independent.

The linguistic assumption under examination is based on the premiss that in any domain there is a large set of words that one would find in any other domain. In other words, not all words are technical. It is suggested that the domain-specific words are usually nouns, but also a percentage of the verbs. There are however a great many other words, including some nouns and verbs but also most adjectives, prepositions, adverbs and so on, that turn up in all subjects but which convey information and from which inferences can be drawn. These words provide the raw ingredients on which our principle of lexical resolution depends.

As an exercise the reader might try replacing all the uncommon nouns in a passage of text with nonce words or variables. The resulting text is surprisingly informative. This is why one is able to have the semblance of a conversation with someone even though most of the technical terms he uses are unknown. It is suggested that there would be theoretical linguistic value in demonstrating that a text or conversation can be coherent even though a large part of the nouns and verbs are not previously known to one of the parties.

The sort of information that can be derived from non-technical, basic, everyday words concerning unknown words can be causal, hierarchical, meronymic, functional, set-theoretical, logically-sequential, temporal, spatial, thesaural, quantificational and so on.

This work can also be considered as a contribution to artificial intelligence.

Artificial intelligence has two strands, commercial artificial intelligence, which has concentrated heavily on knowledge based expert systems, and academic artificial intelligence where systems tend to be idiosyncratic, simulating a particular bit of cognitive behaviour. This work can be considered as a contribution to both, following in the footsteps of, for example, Power's John and Mary system (Power 1974) which simulates conversations, and Davis' Teiresias (Davis and Lenat 1982) which is an expert system knowledge elicitation interface.

0.4 Problems and assessment.

Problems anticipated at the beginning include the choice of a lexicon of basic words of English to be used in conjunction with the lexical resolution principle to resolve anomalies and lexical arcana.

Another important factor is the need to provide a parser and grammar of sufficient power to handle natural

language sentences.

Remaining and lesser problems include the implementation of the program and involve pragmatic questions such as the need to avoid a combinatorial explosion of inferences and questions from the user's input and the best way to arbitrate between a number of them.

Assessment of this research, like its aims, is twofold. On the one hand, it is easy for us to test the validity of the predictions and resolutions made by the lexical resolution principle as to the meaning of unknown words since we have independent lexical authorities like dictionaries to provide us with those meanings.

The other aim of this research is to enhance automated knowledge acquisition. One method of assessment of this function is for the conversation generated by the expert in conjunction with a computer program based on this research to be compared with a human interrogator working with the same expert.

Incidentally, it is important to retain a sense of proportion about the value of natural language computer interfaces. Despite the conclusions of the Alvey Initiative Formal Semantics Workshop (SERC 1987) that, in general, natural language interfaces are of value, and that natural language interfaces make a large range of computer applications available to a wider public, especially since English is a

leading international language, nevertheless, it is quite apparent that graphics, touch-screens, multiple-choice menus and other such devices are adequate and even preferable to natural language for many applications.

However, it is conceivable that knowledge acquisition may, at some time, be possible directly from physical texts with the aid of optical character readers, without the mediation of a human expert or knowledge engineer. In such circumstances some sort of lexical semantics component of the kind to be characterised below would be needed.

0.5 Possible applications and further possible developments.

Possible applications for a system like this with an embedded theoretical lexical semantics component might be interviewing, machine-assisted translation, market-research, teaching, remedial-teaching or therapy. The system could also be used for revising or planning papers on. The primary aim here however is theoretical, in showing the potential of the basic words of English to elucidate the meaning of obscure and anomalous words and phrases.

There are various ways in which this research could develop. One obvious extension is to write an enhanced computer program to generate inferences and questions according to mechanisms other than the ones realised in our semantic principles. A possible development would be to generate system

responses from unknown words by virtue of their occurrence in more than one piece of input, but without any regard for their meaning. This enhancement obviously involves transcending the bounds of the sentence and having some method of discourse representation and analysis.

Discourse representation would also enable questions to be generated from two or more input sentences. For example, if the user entered

X causes Y

and

X is a type of Z

it would be meaningful to ask whether all types of Z caused Y, regardless of the meanings of X, Y and Z. It should be obvious what input would generate the following responses:

X and Y are related to Z; how is X related to Y?
Z is X and Z is Y; when something is X is it always Y?

However, the current research is primarily concerned with the lexical semantics of the sentence, and thus, at this stage, excludes extra-sentential inferences and also marginalises logical inferences on which much research has been concentrated already.

Enhancements to the lexical resolution principles would include using not only words that stand in a certain syntactic relation to an unknown word to infer the meaning of that unknown word

but also *exploiting* the whole sentence in the knowledge that every word in a sentence may have a semantic influence on the meaning of an unknown word in that sentence.

0.6 Parsing and building logical form.

While parsing is not the subject of this thesis a few words should be said on the subject.

The young linguist can be dismayed by textbooks stuffed with italic script that deluge him with tortuous and unruly data. The examples come thick and fast and one abandons any intuition one had that language is basically tractable. This is largely an illusion. Just as a programmer spends 90% of programming time on that 10% of input which is non-standard, so architects of linguistic theory must account for those things practitioners of the language would call oddities. It is as important not to abandon one's intuitions for the sake of non typical data as it is not to abandon the data in favour of a favourite grammar.

There is, however, a multitude of common phenomena that we might want a natural language processing program to handle. It is probably true though that a program that could not handle them would not be restricting the transfer of knowledge so much as restricting the fluency of expression of the user. There are usually other ways to say things. What is important is that information is not lost.

It is important for morale, however, to find a vantage point from which the linguistic jungle can be surveyed and charted. We forfeit granularity for the sake of a manageable classification system. The premiss is that most linguistic constructions can be assimilated under one of the following syntactic types: nominal, verbal, adverbial or adjectival.

Thus, the group of linguistic constructions we call nominal includes all nouns including proper nouns, dates and abbreviations but also gerunds and dummies like 'it' and 'there', for example,

eructating is rude
there is an oubliette under here

and also some infinitives

to eructate is rude.

The nominal class also includes noun phrases

the man that should our king hae been

quantified noun phrases, for example,

two thirds of all Celtic players
any three plongeurs
ten solders
some of us
all the Soroptomists

and also complex nouns such as

air-raid shelter
bus shelter.

A number of different constructions besides simple adjectives and gerundives can be deemed adjectival, for instance, relative clauses

that should our king have been

tough-complements, for instance, (the non-parenthesised)

(Birkin is) impossible to rouse

verbless clauses,

(Rose Macaulay entered,) the camel behind her

post-modifiers

(the Church) militant

(why does she walk through the field) in gloves

(the fat white woman) whom nobody loves

(the man) to do the job (is Fingers Bailey)

and many predicative adjuncts that behave in an adjectival way but include noun, verb and prepositional phrases

(Tramplasure is) eager to go

(Greeble is) easy to dupe

(Birkin is) clever at ping-pong

(Birkin is) in the fireplace

(Greeble is) the boss.

Curiously, passives are more adjectival than verbal and in some cases have crystallised into adjectives:

(the loggia was) painted

(the cleats were) well-wrapped

Verbal constructions include all the verb tenses, modals and phrasal verbs, for instance,

wrap up (the cleats Birkin)
(Trampleasure) is going to see (the proprietor)

Adverbials include verbal and sentential adverbs and
prepositional phrases, for instance,

(don't do it) again (Birkin)
(do it) thoroughly (this time Birkin)
(stand) beside the fancy goods (Birkin and for goodness' sake
smile)

Of course, the above analysis is incomplete and linguistically
facile. Moreover, it does not address the problem of conjoined
or embedded sentences nor other sorts of sentence (for
instance, the interrogative). However, it does provide a rough
and ready classification system for linguistic phrases that
serves to disentangle somewhat the rebarbative syntax of
sentences.

There remain two not insubstantial obstacles to successful
parsing in the form of incomplete and disjointed sentences.

Sentences can be disjointed as a result of unbounded
dependencies of many kinds including relative clauses,
wh-questions, topicalisation et cetera

gravadlax, I like
the man that should our king hae been, wore the royal red and
green
of all the plumbers I know, Heptonstall is the best
I will wrap the cleats up for you, sir

They may be incomplete as a result of gapping or ellipsis.

Birkin likes Victor Mature and also Gloria Swanson
Trampleasure lives near Greeble

It is beyond the scope of this research to write a grammar that can handle all the above linguistic constructions and build logical forms for them. In any case such an enhanced system would not necessarily be a better vehicle for use in testing a theory of semantic inference. For this reason many of the above constructions have been disregarded.

A possible source of confusion should be eliminated here. Parsing can be discussed at a number of levels. Primitively, it is merely the analysis of a sentence or phrase in terms of a grammar, and as such, this is the meaning that is assigned to the word when parsing is taught in school. Before the advent of automatic parsers in the form of computer programs, the notion was straightforward since one was not interested in how children managed to parse as long as the answers were right.

Artificial parsing programs, however, in common with other systems designed to exhibit cognitive skills, must incorporate a specific parsing algorithm which governs the precise manner in which a sentence or phrase is traversed in order to carry out a grammatical analysis. Such parsing algorithms have been the subject of much research and, consequently, the term "parsing" has been used to refer specifically to a traversal mechanism independently of, and without reference to, any grammar.

A further confusion arises when writers and practitioners use

the word "parsing" to refer to the whole business of their natural language program. The temptation is strong. Just as, for a grammarian, to scan a sentence is to syntactically analyse it and construe its meaning as well (it is hard to look at a sentence without reading and understanding it), so, some programs traverse, analyse and construe sentences in one fell swoop. Thus, Sparck-Jones (Sparck-Jones and Wilks 1983) says that she is using "parsing"

to cover both the syntactic and the semantic analysis of a text in order to build a meaning representation for it.

Of course the functions are separable but the compositional semantics adopted allows one program to scan each word and assign a syntactic and semantic analysis to it.

This is not to say that an exhaustive semantic analysis is included in such a process. "Semantic representation" usually refers to some kind of logical form. That there is more to semantics than this is often forgotten (van Riemsdijk and Williams 1986):

an LF-representation is a partial representation of the meaning of a sentence, representing what might be called its "structural meaning" (abstracting away from such other aspects of meaning as the meaning of lexical items and conditions on "appropriate use" of sentences...). If Logical Form were taken to be the complete explication of the meaning of a sentence ... then certain conclusions would follow: Logical Form would have to represent word meanings, since clearly word meanings partially determine the meaning of a sentence; it would have to define (or allow for the definition of) the "truth conditions" of a sentence, since, as philosophers have said, to know the meaning of a sentence is to know, perhaps among other things, what circumstances the sentence would truly describe;

and it would contain, or directly allow for the definition of, the specification of the roles that a sentence could potentially play in such larger entities as discourses and logical arguments.

The logical form spoken of is a version of predicate calculus. This account of logical form applies to such theories as model-theoretic semantics which claim additionally that logical form will yield a set-theoretical interpretation of meaning.

Thus, the work of some semanticists rests on the assumption that it is possible to characterise sentence meaning without reference to context. This can be stipulative: in other words, any rules that transcend sentence boundaries (like those that concern anaphora) can be deemed to be rules of discourse meaning not sentence meaning. Even allowing for such restrictions, it is evident that a great deal may still be encompassed by the simple activity of parsing.

The question remains: which linguistic constructions should our principle of lexical resolution handle? It is tempting to think that the more comprehensive the grammar the more we would be able to demonstrate about the meaning of words. This may or may not be true. However, our assumption is that every simple sentence (that is, without conjunctions) can be reduced to a set of linguistic structures whose function is one of the following: nominal, adjectival, verbal and adverbial, and it is at this level that semantic classification, prediction and resolution take place.

Thus, our concern is not primarily with parsing or grammar but semantics and consequently, in, for example, the sentence

the U.S. forces' fight in Vietnam lasted longer than the Falklands War

we are less concerned with the non-trivial parsing problem of the subject noun phrase than with the semantic contribution the phrase makes to the understanding of the rest of the sentence.

The lexical principles are discussed in detail in Chapters 4 to 7. Chapter 1 deals with different methods of knowledge acquisition and how they compare with the one under discussion here. Chapters 2 and 3 examine the field of general semantics and its contribution to lexical semantics.

Chapter 1. Knowledge elicitation.

1.1 Preview.

The Egyptians extracted the contents of a Pharaoh's head prior to mummification with a little pipe. This chapter is concerned with the systematic elicitation of knowledge from cooperative living sources. By 'systematic' I wish to exclude the acquisition of knowledge by virtue of desultory chatter or drug-induced indiscretions. By 'elicitation' I mean to exclude all kinds of pedagogy which is rather concerned with the systematic dissemination of knowledge. By 'knowledge' I wish to exclude say, the results of the disingenuous midwifery of Socrates, which merely brought forth his own progeny. By 'cooperative living sources' I want to exclude not only Pharaohs and torture victims but also texts and other media since this work is primarily concerned with the acquisition of knowledge from human beings, typically experts in some domain, although some of the techniques described later could be applied to a corpus of knowledge acquired directly from texts by, say, an optical character reader.

As we saw above, automated knowledge elicitation is one of the two arms of this research. Knowledge elicitation is a subject that has exercised the minds of psychologists, knowledge engineers and even philosophers.

Knowledge elicitation in artificial intelligence is the automatic extraction of knowledge (definitions, facts, rules,

heuristics, strategies and so on) from someone or something who knows, and the storing of it in a computer as the foundation for some kind of knowledge based system or expert system. Such systems are typically designed for a particular task such as medical diagnosis or oil prospecting or something of that kind. They are heavily dependent on a specific domain of knowledge as opposed to general purpose systems like, say, file handlers that can perform a number of general functions on any old files. Knowledge based and expert systems are a natural extension of one of the computer's original functions which was the storage and retrieval of information. Now computers are required to do something intelligent and this means not just storing transient information like, for example, 'Mr Podsnap's insurance policy number is XYZ123 ' but domain information such as 'if a man has smoked for forty years his premium will be increased'.

Knowledge elicitation is sometimes called knowledge acquisition. (A confusion should be guarded against namely that in expert systems the phrase knowledge acquisition can mean the process that takes place when the system has already been built but is running a diagnosis and requires more data from the user to enable it to reach a conclusion. In artificial intelligence the phrase knowledge acquisition is sometimes used in association with machine learning. While there are parallels with knowledge elicitation and machine learning, the latter is less concerned with interaction between man and machine and more with abstraction of principles from a large body of given

data. To that extent it is only tangential to this work.)

It is obvious that the sort of domain knowledge or expertise described above must be got into the computer somehow. This is a hard enough task when the information is merely raw data such as that on a library catalogue where the acquisition of the hardware and software may be greatly in advance of the collation of the thousands of book titles. It is a much harder task when the knowledge base must be built painstakingly out of the knowledge and expertise, perhaps as yet unformulated, of a living expert. This is why knowledge elicitation systems, designed to help experts give up their secrets, are important.

Of course, what knowledge is, and what different kinds there are, is a philosophical question in itself. A number of dualisms pop up frequently: declarative versus procedural, compiled versus uncompiled and physical versus mental. While this question will be discussed in more detail later on, a few myths should be exploded. Declarative knowledge (like facts, conceptual knowledge and classificatory knowledge) can be expressed as procedural knowledge and vice versa. Compiled knowledge (which includes heuristics and automated skills) could, theoretically, be represented as uncompiled knowledge and vice versa. (See Bundy (Breuker 1983) on heuristics as meta-level knowledge. See also Heefffer (Heefffer 1984) on an inductive method of turning grand-masters' chess heuristics into rules comprising features and background knowledge.)

Experts may claim that what seems to be compiled knowledge is just intuition or a hunch (Waterman and Newell 1971). All we are saying is that the raw content of knowledge may not be as disparate and unruly as our habitual forms of expression of knowledge may suggest.

The relevance of knowledge elicitation to us as a body of research is limited to those techniques that do not involve a schema or higher order plan but are restricted to lexical extrapolation from what has been said. It is true however that lexical inferences themselves can sometimes impose a schema on the verbal exchange taking place. The main difference is that while, in medicine, one might have a knowledge elicitation schema for, say, cirrhosis, containing slots like degree of alcoholism of patient and colour of tongue, in this research, on the other hand, there are meta-schemata of generic knowledge structures like animacy or concreteness, or class-membership or sequentiality. Thus, if our knowledge-source volunteered

X precedes Y
Y pursues Z

lexical inferences generated by the words 'precedes' and 'pursues' could be invoked, concerning logical, physical and temporal precedence, animacy and so on.

What direct precursors are there to the current work in knowledge elicitation research? Knowledge elicitation techniques include multi-dimensional scaling, repertory grids, Weizenbaum's ELIZA (Weizenbaum 1966), interviewing techniques,

conversation transcripts and so on.

The aims of disparate disciplines have of course been different although their subject matter is the same. Philosophy, or that branch of it called epistemology, is predominantly concerned with verification and has only a tangential concern with eliciting knowledge, although Plato's Socratic dialogues, on the occasions when they do not come uncomfortably close to bludgeoning into submission, might possibly be seen as devices for teasing out the confused and fibrous mass of knowledge in a pupil's head.

Psychologists concerned with knowledge and cognitive modelling have been interested in general domain-independent strategies across tasks that have a family resemblance.

Knowledge engineers, and those in artificial intelligence and computing, have a different perspective again. Psychological research into the best way to extract knowledge from people or assess their knowledge, has been exploited by a number of computing systems which will be surveyed briefly. At the back of one's mind though one will be aware that such knowledge elicitation systems have been designed as an interface to expert systems which, typically, are not domain-independent but special-purpose. (Some attempts have been made however to develop domain-independent interfaces to expert systems, for example TEAM (Grosz 1987).)

Thus, there may be an implicit belief that the knowledge

elicited is appropriate for the construction of rules or the hierarchical representation of problem-solving. This can drive and circumscribe what the expert user is allowed to say. In fact the system won't 'listen' to that knowledge that it can't encode.

Another important point is that research in knowledge elicitation for expert systems is not motivated by a desire to improve the elicitation process so much as by the fact that knowledge representation systems are so complex that they require a human or automated intermediary to make them accessible to an expert. As Davis says of the knowledge elicitation system TEIRESIAS (Davis 1977):

part of the task ...involves...establishing a discourse at a level high enough that we do not end up effectively having to teach ...[the expert] ...how to program.

A number of systems still depend on a system designer's or programmer's expertise when running their knowledge acquisition facilities, for example Ginsparg's system (Ginsparg 1983), LDC-1 (Ballard 1984), EUFID (Templeton 1983), IRUS (Bates 1983) and Chat-80 (Warren 1982). Others require the user to have knowledge of natural language processing and database concepts, for example, ASK (Thompson 1983).

It is impossible to overestimate the degree of opacity a computer system has to the new and even experienced user. A non-existent or partial model of the system in the user's head trammels him in what he wants to do. Some recommend that the

user be shown the structure of the system's knowledge base or examples of other domains as long as the system is not more obfuscating than the interface.

We should now look at existing knowledge elicitation methods and compare them with the elicitation method of lexical inference.

1.2 Personal construct theory and repertory grids. -----

This technique, described by Gaines and Shaw (Gaines and Shaw 1980) was invented by Kelly (Kelly 1955). The 'personal scientist' that is you, me or anyone, acquires a model of his world; he continually builds constructs or 'templates' to filter perception to allow past experience to relate to future behaviour. The idea is that we anticipate the future by construing the replication of events.

Kelly's notion has been endorsed in other quirky formulations such as Brown's (Gaines and Shaw 1980):

a universe comes into being when a space is severed ...
by tracing severances you can uncover the basic forms
of linguistics, maths, physics and biology.

Adams-Webber (Adams-Webber 1979) describes how to elicit from someone the constructs that he filters perception with:

...a triad...[of persons or objects]...is presented to the subject and he is asked to 'think of some important way in which two of these three persons are similar to one another and different from the third'. Whatever the subject states to be the basis of perceived similarity and contrast is

recorded verbatim as a single bi-polar construct, for example, reserved-outgoing. A series of triads ... is used to elicit twenty or thirty bi-polar constructs from each subject.

Weightings assigned to each construct determine the relative significance attached to similarities between elements.

The technique can generate a repertory grid where equivalent constructs can be discovered and clusters of constructs mapped. In the system AQUINAS (Boose and Bradshaw 1987), a set of elements or objects are chosen by the subject. A number of traits are chosen which serve to group the objects in different ways. Sometimes three objects are isolated and an odd-man-out test will reveal a relevant trait. A grid is then built with the objects or elements along one axis and the traits along the other. The traits are expressed as polar pairs. The expert then fills in the grid with ratings, say, on a scale of 1 to 5.

AQUINAS offers a tool to help the expert build such grids, as does the PLANET system (Gaines 1987). Boose claims also that the distinctions captured in such grids can be converted to other representations, for example, production rules, fuzzy sets or networks of frames, but doesn't say how. Possibly the expert has to do it himself.

Here is an example dialogue where personal construct theory is being applied.

Q What's the domain?

A My colleagues.

Q Choose 6 elements of the domain.

A Maud, Arthur, Vernon, Stanley, Alf and Beat.

Q Choose 2 of the following, Maud, Arthur and Vernon, that are the same and 1 that's different.

A Maud is different.

Q What 2 words describe the poles in this polarisation?

A Pretty and plain.

Q I will assign 1 to pretty and 5 to plain; please assign numeric values to the rest of the 6 people.

...
(more trait elicitation)

...
Q There's a 95% match between the elements Maud and Beat; do you want to conflate them?

A No.

Q Think of 2 words to describe a polar distinction between them.

A Part-time employee and full-time employee.

Q I assign 1 to part-time employee and 5 to full-time employee; please assign numeric values for the other 4 people.

...
Q There's a 75% match between constructs fat/thin and happy/unhappy; if you don't want to conflate them, name the element that differentiates between them.

and so on.

This dialogue resembles quizzical exchanges that even children can handle.

Q Who's your friend?

A Vernon.

Q Who's he like?

A Alf.

Q Why?

A They've both got specs.

Q Has everyone?

A No.

Q Who hasn't?

A Vera.

Q What's she like?

A She's got freckles.

Q Has Alf got freckles?

and so on. Thus, the identification of traits prompts for more elements and vice versa.

Gaines and Shaw's system PEGASUS (Gaines and Shaw 1980)

elicits personal constructs, with analysis and feedback and directs further elicitation. It builds a repertory grid and re-groups constructs according to the user's ratings. It also conflates constructs that are used in the same way. This technique is also used in the KRITON system, a knowledge acquisition tool for expert systems (Diederich et al 1987).

AQUINAS (Boose and Bradshaw 1987) is an advanced version of an earlier system called ETS (the Expertise Transfer System). It claims to build rapid (two hour) prototypes and to create knowledge bases for various expert system shells such as S1, M1, OPS5 and KEE.

Among its sophisticated operations are handling knowledge elicitation from more than one expert, reasoning at different levels of abstraction, the elicitation of traits, the decomposition of problems, the handling of uncertainty, case-driven and knowledge-driven elicitation and the employment of an enhanced personal construct theory.

The structure of the system is as follows.

```

dialogue
manager  <-- < ( repertory grid tool
                  | hierarchy tool
                  | induction tool
                  | internal reasoning tool
                  | uncertainty tool
                  | multiple scale tool
                  | multiple expert tools
                  ) > <--common Loops/
                           common Lisp

```

Before looking at this system in more detail, two things stand out. One is that the system is built using the

object-oriented architecture Loops which facilitates programming by using inheritance lattices of objects. A number of programs have been built on top of this kind of structure but we should remember that each stands on its own merits. Object oriented programming is labour saving for programmers but this doesn't necessarily mean that it is the best way to do knowledge elicitation, knowledge representation or whatever.

The second point is evident in the diagram. AQUINAS claims to offer an integrated toolbox. However, it seems the only integrating property is the box. (Motta's system KEATS (Motta 1986), developed at the Open University, is an example of a bundle of knowledge elicitation aids that are only integrated in a geographical sense.) An enabling mechanism is not really the same thing as a helpful one. A spade may enable one to dig a garden but one would require more positive action from it for one to describe it as helpful. Similarly a mechanism that merely enables one to give up one's knowledge cannot be said to positively elicit it. Of course a good representation method, for example, a sketchpad to a cartoonist, undoubtedly results in a greater transfer of information and it is for this reason that some of the methods outlined below have been called elicitation techniques when they are really representation techniques. After all a representation technique can serendipitously reveal a structure inherent in knowledge that the user didn't know was there and may inspire him to be even more forthcoming.

Gammack and Young (Gammack and Young 1985) describe the advantages of repertory grids.

.....this technique seems appropriate when there are a number of closely related concepts, typically not well differentiated by novices, and expertise consists in being able to make discriminations. In addition there may be no specialised vocabulary to describe such subtle distinctions and relationships ...In such cases repertory grid can elicit finer-grain criteria than can the interview method... Clustering gives the structure that differentiates these domain objects from one another.

A further technique is multi-dimensional scaling where it is assumed that the concepts are in multi-dimensional space; pairwise similarities are obtained between all objects and an algorithm is applied to determine the number of dimensions and the best-fitting placement of objects. If, for any two concepts, all elements of the domain are construed in the same way in relation to them, then they are zero distance apart and equivalent constructs. If a number of constructs are close they can be clustered.

There are certainly interesting questions that can be generated from Kelly-type grids, for instance:

Is there any solution that you would give rating 2 for trait X for?;
A is less B than C; is there anything that is more B than A but less B than C?;
A and B have rating 5 for trait X and C has rating 4: what trait do A and B have that C doesn't?;
Rating for trait X and Y are always the same; is there an example where they aren't?.

Boose (Boose 1985) admits grids are best suited for analysis problems (like diagnosis and classification) rather than

synthesis ones (like design and planning) or causal, procedural and strategic knowledge elicitation. Even so it is not clear to what extent conceptual knowledge is as tractable and modular as Boose's method suggests.

Boose admits experts find it hard to decide on questions of modularity and levels of granularity. He also says that there may be a clash of levels. For instance, suppose the objects (or options) in a car repair problem are 'engine', 'battery' and 'electrics'. They would not necessarily occur at the same level in a hierarchy of objects.

As Boose points out, there are abiding problems with repertory grids, for instance, their inability to represent deep or causal knowledge or representation chains or non-unary predicates, the restriction to one level of abstraction and the difficulty in comprehending large grids.

I think the latter is a problem inherent in all computer representation formalisms however. One of the prime functions of computers is the storage and retrieval of vast amounts of knowledge. We should not be suprised that we cannot apprehend it all in all its complexity at once. Indeed one of the motivations behind expert system development is to enable the collation of evidence from more than one source, expert or discipline. Experts find it hard to keep up and communicate with bordering disciplines (Hawkins 1983). A knowledge based system on an oil rig, for example, would draw on many diverse branches of expertise that no one person could assimilate .

There does seem evidence however that large repertory grids are unmanageable and fatiguing to use.

Another problem is the non-binary nature of some traits. How do we polarise, for instance, a black man, a white man and a yellow man into two groups according to colour? Boose claims (Boose and Bradshaw 1987) to have extended the elicitation methods to handle other types of rating, for example, by allowing nominal values (e.g. A,B,C,; Chinese,French,German), interval values (e.g. 32 degrees F - 212 degrees F) and also values with an absolute origin (e.g. 0.0, 0.1, 0.2).

There is another problem with the acquisition process of AQUINAS. Suppose the expert is describing possible solutions for a problem in his domain. He is asked for the problem, the solutions, traits that these solutions share, a suitable rating scale for traits and also for a rating of the importance of each trait to the problem in hand. It seems unlikely to me that one could rate the importance of one trait in isolation. Suppose that the problem is

What should I do at 5 p.m.?

and the solutions are to return a library book or to ring Arthur. The trait that they share is thriftiness since to return the book will save me a fine (thrifty) but to ring Arthur will cost me 50 pence (unthrifty). The importance of the trait to the problem I rate highly because I am penurious. However Arthur may offer me a job in which case the rating

would change. In other words we often cannot say "solution Z is better than solution Y" but only "if W then solution Z is better than solution Y".

This problem is one we could really have anticipated since the knowledge elicitation method employed is really only suitable for gathering concepts and not for procedural or heuristic knowledge. Other systems, such as the MOLE system, acknowledge the complexity both of inter-related evidence in problem-solving and the algorithm for finding solutions. Evidence can be explanatory, expressing a tendency, expressing a negative tendency, expressing a positive or negative correlation, refining or supporting.

Another problem with all knowledge elicitation systems that require an expert to give ratings, weightings or probabilities is that it is not particularly easy to do nor a favourite method of expression, though ranking or frequency rating is easier (Kidd and Cooper 1985). Expert assessment has been found to be inconsistent, empirical rather than statistical, and undeliberated:

Widdecombe is painfully shy; is he more likely to work as a librarian or a shop-assistant?"

will elicit a response according to prototypicality, namely "librarian", regardless of the fact that there is a much greater population of shop assistants than librarians.

Weights are even harder to calculate. Co-occurrence suggests

causation but non-co-occurrence and negative weights are usually not noticed (Wason 1972). Subjective fouling is a hazard: people usually think saving 10% of £10 is better than saving 1% of £100 although this is only true in one sense. A probability rating is a bit of a black box anyway since all the reasons it rests on are lost. Precision of ratings doesn't necessarily help problem solving or machine efficiency anyway. A rating scale with verbal calibrations is less rebarbative and slightly easier to handle (for example, not very probable, quite probable, probable, very probable, almost certain).

In the PROSPECTOR system (Duda 1978), the experts' verbal ratings (for example, "encouraging evidence") are converted and refined. We need, after all, some method of storing vague information. The medical diagnosis expert system shell MOLE defaults to giving high values for traits spontaneously mentioned and low ones for others.

Another problem with Boose's system is that AQUINAS, like other systems, asks sophisticated questions like:

Why is trait X important?;
Under what circumstances would solution Y have trait X?;
Under what circumstances would the maximum value of trait X increase?.

Just as a schoolboy learns how to ask "Où se trouve le Louvre?" long before he can comprehend all the possible answers that he will get, so it is easier for elicitation systems to ask canned questions than to parse or process the answers

intelligently.

1.3 Concept-sorting and hierarchical clustering.

Gammack and Young (Gammack and Young 1985) describe another knowledge elicitation technique, namely, concept-sorting:

obtain a set of concepts that broadly cover the domain ...from a glossary or text...The next step is to transfer each concept to a card and ask the expert to sort the cards into a number of groups describing what each group has in common. The groups can then be iteratively combined to form a hierarchy. The method is applicable when there is a large set of concepts, ranging across the whole domain, which require a suitable structuring to become manageable.

This technique is similar to laddering where the expert is asked to name the important concepts in the domain and the knowledge engineer asks about broader and narrower terms related to them. These terms can be known as supertypes and subtypes, classes and subclasses or generalisations and specialisations. Laddering can also be performed on concepts representing actions or goals (Gaines and Shaw 1980). The question

How do you achieve goal X?

will generate sub-goals; the question

Why do you attempt goal X?

will generate higher-order goals.

Similar reservations must be made about this technique as

about the ones above. While claiming to elicit concepts, it is not proven that concepts are as modular or tractable as this. Kelly (Kelly 1955) says:

there is a natural hierarchy among constructs...constructs are construed by means of other constructs and so on ... to form a system.

However, pace Kelly, a hierarchical structure is not inherent in every domain of knowledge. Some domains appear to contain identifiable concepts but ones that stand in associative or net-like relations. What are the concepts of mathematics and what is the hierarchical structure inherent in literary criticism? In Eshelman's system MOLE, it was discovered that doctors failed to recall some elements of their domain unless they could work through a test-case or particular example. They also had a proclivity to think in causal chains anyway rather than in terms of objects.

Hierarchical clustering (Olson 1986) is a similar technique. Those items that are most similar are clustered together and then this cluster is assessed for similarity with the other items, and so on until a hierarchy is built up with an ultimate cluster that contains all the others. Similar methods are ordered-trees-from-recall (Olson 1986) and drawing closed curves (the latter yields sets rather than a hierarchy) (Olson 1986).

Under this heading, in the field of machine learning, we should also mention taxonomic classification programs like CLUSTER

(Michalski and Stepp 1983a) that determine hierarchies of sub-categories within a collection of objects. Such programs are particularly suited to practical classification problems involving conceptual descriptions, and have been used to classify soybean diseases (Michalski and Stepp 1983b) and for the classification of Spanish folksongs.

1.4 Automatic thesaurus construction and text analysis.

This method of knowledge elicitation is taken from the world of information retrieval systems and was devised by Salton (Bezdek 1986). While it addresses the question of converting textual knowledge into some formal representation nevertheless there are enough similarities between texts and human conversation for it to be worth looking at.

A frequency count is taken of the words in a document collection. Each document is identified by the high-frequency words in it. The information is represented in a matrix (being terms x documents) and then similarity coefficients between terms are computed, based on co-occurrence characteristics of the terms in the documents. (This notion of word frequency analysis has incidentally been taken up in semantics as a technique to elucidate word meaning and also in discourse analysis, repetition being deemed to be an indicator of the deep structure of discourse (Sinclair and Coulthard 1975)).

It is stretching a point to call this a knowledge elicitation method as it does not really elicit new conceptual knowledge.

Static knowledge such as documents and books has been considered as a source of knowledge elicitation, both traditionally as the required 'homework' of systems analysts, and in computer systems, for example, the KRITON system will supply word frequencies for use in conjunction with its other knowledge elicitation methods. This method has also been used to extract action-event models (Nishida et al 1983) and for discourse representation (Frey et al 1983). Krippendorff (Krippendorff 1980) gives an introduction to its methodology.

1.5 Concept mapping.

This is described by Novak (Novak 1986).

Concept maps are intended to represent meaningful relationships between concepts in the form of propositions. Propositions are two or more concept labels linked by words in a semantic unit ...for example 'sky is blue' would represent a simple concept map forming a valid proposition about the concepts 'sky' and 'blue'.

He goes on to describe the uses of the method.

Concept mapping is a technique for externalizing concepts and propositions...Undoubtedly we may develop new concept relationships in the process of drawing concept maps especially if we seek actively to construct propositional relationships between concepts that were not previously recognised as related ...we have frequently found that concept maps are remarkably effective tools for showing misconceptions.

Callman (Callman et al 1985) suggests how the technique could be automated.

When a new concept is entered, the computer should prompt the user with an appropriate set of relationships. Menus should be available summarising all available relationships ...

Such maps can help you know what you know and what you don't know. Some graphical computer interfaces like Xerox-Parc's Loops environment can help you construct very large concept maps on the screen. The main and fundamental disadvantage is that unless one wants to restrict one's expressive power to two-place predicates, that is binary links, then one has to invent some more sophisticated formalism for the graphical representation. This has of course been done in the wide field of semantic networks for knowledge representation. However this severely compromises the intuitive 'sketchpad' quality of the original concept mapping idea.

The technique of path analysis or influence diagrams (Olson 1986) is designed to show functional relations between items and the relative weights of these links. The completed diagram should show which links are the most significant in a knowledge system where there are functional connexions between the concepts.

1.6 Interviews and questionnaires.

This is the oldest and most obvious method of getting someone to tell you something and any technique of knowledge elicitation involving two human beings could be described as interviewing. If you know the domain already and merely want to

know the values of its variable data in this particular instance, then a verbal or written questionnaire is all that's needed. This kind of menu-driven knowledge acquisition has even been used in domain-independent systems like TEAM (Grosz 1987) (although strictly speaking the domain is English grammar) and the knowledge acquired can be terminology from any domain.

Questionnaires are the usual method of data collection for on-line interactive systems in business and industry. They are translated to the VDU but are no different in principle from the kind of clipboards wielded by market researchers in the street.

Questionnaires are a very good way of securing discrete and relevant packets of information about something. In an interview, on the other hand, as with protocol analysis below, even a highly manipulative interviewer cannot guard against receiving irrational, illogical, probabilistic, non-deterministic, vague, incomplete or compiled (Ericsson 1980) information. On the other hand one can focus on a particular subject or explore low probability events.

Gammack and Young describe one approach (Gammack and Young 1985):

....ask the expert to...lay out the main themes and ideas of the domain. Later systematic probing interviews can pursue the relevant areas to a greater depth ...[by]... generalised checklists ...critical incidents...[etc]....

Among non-automatic interviewing techniques Grover (Grover

1983) includes forward scenario simulation which involves an expert describing a problem scenario and identifying the terms, concepts, required information and reasoning strategies involved. A number of these scenarios or cases can be collected and clustered or sorted according to prototypicality. This is similar to critical incident analysis where an especially memorable event or problem is discussed (Flanagan 1954). This is more accurate than theorising about generalities if the area of expertise is not task analysis but problem solving.

Other strategies are goal decomposition where the expert analyses a problem into sub-goals and methods of achieving them, goal-distinguishing, where each diagnosis is taken and the expert is asked what evidence is necessary and sufficient to distinguish it from others, what is a typical case of it, what evidence would support it and what evidence would rule out every other hypothesis (Clancey 1986). Alternatively the reclassification method can be used where each goal is reclassified into the set of facts that produced evidence for it and these re-classified until facts are reached that are data observable by the expert (Grover 1983). Some problem solving data may be so tractable that a symptom/fault grid can be used (symptoms x faults). A more top-down method is typing where a case and a class of cases are taken and the knowledge engineer will ask:

does the case fit the class?;
what is the evidence for and against the fit?

and so on.

Induction from examples can also be used as an interactive method of knowledge elicitation (Michalski 1983).

Protocol analysis (see below) can also be conducted as an interview as can the various concept-sorting techniques we have seen above.

Interviewing techniques can be hard to implement on a computer. The nearest thing to interviewing is performed by systems like TEIRESIAS (Davis and Lenat 1982) that use a sub-set of language to confirm or qualify knowledge entered by the user.

TEIRESIAS was developed because, in MYCIN (a production rule expert system), it is hard to set up and trace rules. The idea is that TEIRESIAS provides a link between the expert's natural language expression of his expertise and the highly formalised rule notation of the expert system. The current rule-base is presented to the expert in a palatable form and he is prompted for amendments and alterations that will improve the system's diagnostic abilities. It is important to realise that the structure of the system is rigid and the interview engaged in is highly schematic and circumscribed. Davis and Lenat (Davis and Lenat 1982) say

Natural language has not been a major focus of this work... All questions and responses from TEIRESIAS are either pre-formed or based on a simple template completion mechanism... Responses from the users are of three general types: single token answers to multiple choice questions,

strings belonging to a synthetic language with a formal grammar, and heavily stylised natural language sentences using a restricted vocabulary...

Nearly all systems have this restriction. PEGASUS (Gaines and Shaw 1980) claims to engage in 'conversational dialectic' but the authors would probably agree that it is conversation of a laconic sort. TEIRESIAS can indeed formulate complicated questions of the sort:

what is it that you know and the system doesn't that allows you to avoid making that same [diagnostic] mistake?

but it is not clear, as with AQUINAS above, how well it would cope with processing the answer. There are indeed other artificial intelligence programs that ask questions but again only in highly formalised micro-worlds, for instance, Heeffer's chess strategy induction program (Heeffer 1984) can ask yes-no questions and reconstruct a chess position.

One should mention an automated interviewing system at the opposite end of the scale in terms of expressiveness and functionality. Weizenbaum's ELIZA allows uninhibited expression of natural language to be entered but has no knowledge representation or inference component. It simulates a psychologist giving therapy, providing template-built responses triggered by input words. Hasemer (Hasemer 1984) says

The intelligence lies in a clever pattern-matching algorithm which can pick the key-words out of input sentences; in the set of keywords itself which clearly embodies some notion of how a sentence is understood by a human listener; and in the set of responses that the machine can generate...

An example exchange from a version of ELIZA might be:

USER My mother hates me
ELIZA Tell me more about your family

Recognition of the keyword 'mother' generates template-built questions about family relationships. The conversation can be can be both convincing and provocative. It is however easy to confound ELIZA.

USER I must be going now
ELIZA How does it feel to be going?
USER I am going now
ELIZA Do you know anyone else who is going?
USER I am going now
ELIZA Do you belive it to be normal to be going now?

and so on!

This cannot properly be called a knowledge elicitation system because it does not store the knowledge received nor does it have a principled method of extracting it. However the parallels are obvious in that the system does accept information, recognise words in it and prompts for more. Although the algorithm seems facile to us now, it has yet to be demonstrated that the most efficient programs are the ones that embody the most exhaustive set of grammatical and semantic mechanisms. Cognitive simulation and computational efficiency don't always go together. Moreover it is not yet clear what cognitive processes are employed in conversations anyway. Boot and Koppelaar (Boot and Koppelaar 1982) say

A natural language understander does not attempt to parse everything he reads or hears. He determines what is most

interesting and concentrates on that ignoring the rest...This verbal depth of processing is based on the extensive use of patterns learned in the past...We should give our machines the same knowledge of those patterns.

1.7 Protocol analysis.

This method is suitable for eliciting the expertise involved in problem-solving or manual tasks. Gammack and Young (Gammack and Young 1985) describe it.

....behaviour (verbal or otherwise) is recorded as an expert works through a problem and this protocol is transcribed and analysed, by (ultimately) converting it to a set of productions that transform one solution state to the next...
... by reconstructing the system using inferred production rules the expert's knowledge can be modelled ...such a method is particularly useful for eliciting procedures that experts use in problem solving, which they may not be able to articulate...

Waterman and Newell (Waterman and Newell 1971;1973) describe a protocol analysis program. The utterances of a human problem solver are tape-recorded. The program segments and reduces the transcription to:

- a) entities about which something can be known;
- b) expressions about the entities;
- c) a production system (i.e. rule = condition + action) that can be applied to b).

The system PAS-I elicits knowledge about cryptarithmic. It is not clear to what extent the segmentation and rule-production tasks are automated. Waterman explains that topics can be identified using syntactic and prosodic information but doesn't say how this is achieved.

The system KEATS (Motta 1986), described as a 'knowledge engineer's assistant', has a knowledge elicitation interface built on protocols as has KRITON (Diederich et al 1987).

However, these systems merely allow protocols to be entered which must then be segmented by the user, either by a bottom-up search for patterns that can be used to modularise the text, or top-down segmentation according to a prior hunch about the structure of the problem.

One of the difficulties about any discursive account of a process, it seems to me, is that the structure of the peroration is not necessarily isomorphic with the structure of the process. For instance, a carpenter might say something like: 'if the sanding belt is damaged whilst sanding this may be because of projecting nails so always make sure you have hammered them all in first' rather than 'first find any projecting nails; then, hammer them in ; then ...' and so on. By analogy, there is no reason why a lecture on, for instance, anatomy should be isomorphic with a skeleton.

The overriding strategy of protocol analysis can be to produce one of three things (Breuker and Wielinga 1983):

- a flow of control (i.e. in the form of a goal/subgoal analysis), for example, peel the spuds, chop the chips, boil the oil etc.;
- a flow of data, for example, charting the course of a King Edward through the oven-bake chip factory;
- a body of rules, (possibly acquired by translation from declarative information), for example, 'if the potato is more than 3 months old the chip will be flaccid'.

Protocol analysis, or 'thinking aloud', can be tortuous and lengthy, especially if the expert is thinking in images. It may be impossible if he depends on recognition of given objects rather than a verbal description he has committed to memory.

Recognition is easier than recall. (It is difficult to recollect a penny, for instance.)

Protocol analysis can be concurrent with the problem solving itself or retrospective. Recollection in tranquillity may seem attractive but it is slightly hazardous.

A systems analyst once told me that, when he was automating a woolmill, a retrospective protocol analysis failed to provide enough information for the system to be written. On taking a stroll round the plant to observe and question the staff in action he found a machine operator tossing a ball of wool into the air: 'What are you doing that for?'; 'Well we wouldn't know it was the right weight otherwise would we?' Needless to say, this crucial part of the procedure had not been recollected.

Protocols have the advantage of allowing the expert to ramble freely without loss of expressiveness. This of course means that the resulting text may be discursive, sequential, highly deictic, generalised, highly specific, anecdotal, unstructured, capricious, superfluous and abounding in terminology, text-book fictions (Feigenbaum and McCorduck 1983) and shorthand explanations. The one thing it probably won't be is in the form of rules! In fact it seems more than likely to me that the problem-solving process is more like a procedural computer program (Barstow 1979) than a set of axioms and that a program qua algorithmic device is verbalised most easily as a set of questions, answers and actions. The knowledge engineer can manipulate the dialogue if he is

sufficiently well briefed in advance.

Protocols are also not immune, as any other elicited knowledge, from incompleteness, error, lacunae, partial memory and post hoc justifications.

1.8 Review.

In a critique of the above methods the declarative/procedural distinction comes in useful, as it often does. This is because most of the methods cited above are either overly concerned with concepts (personal construct theory, multi-dimensional scaling, concept-sorting, automatic thesaurus construction, concept mapping, hierarchical clustering, drawn closed curves, ordered trees from recall, influence diagrams) or procedures (interviews (with the exception of ELIZA) and protocol analysis).

There are problems in the elicitation of concepts. As Gaines and Shaw remark (Gaines and Shaw 1980) of personal construct theory, there are other more meaningful relationships between concepts than just similarity. The poles of two constructs may be distinct in terms of equivalence but close in terms of entailment (alive and dead?). (Gaines' and Shaw's system attempts to extrapolate such knowledge from repertory grids.) Another problem is that if one admits of shades of grey between the two poles of a construct one doesn't really know whether the mid-point means:

this element is halfway between the poles;
this element is assigned to both poles;
this element is applicable to neither pole;
this element is under one pole sometimes and the other other
times;
this element is I don't know where;
this element cannot be construed this way.

The other methods of eliciting concepts have problems too. For one thing they may capture conceptual relations but not logical, causal, functional and other relations. Path analysis captures functional but nothing else. The need for developing functional, causal and structural models of the domain has been stressed in artificial intelligence (Davis 1983; Sembugamoorthy 1986; Clancey 1986; Patil 1981). Also, conceptual knowledge may require a backing group of other types of knowledge like examples and analogies (Newell 1973):

American psychology has largely identified the central problem of conceptual behaviour with the acquisition or formulation of concepts, which in practice has turned out to mean the induction of concepts from a set of presented exemplars.

It is a pragmatic question whether those exemplars should themselves be considered as part of a person's knowledge or whether knowledge should be considered to be just those concepts he has derived from them. Most expert systems, in the absence of a facility of inductive inference, would not know what to do with such information. Quinlan's induction program ID3 (Quinlan 1982) and Niblett's CLEAR (Niblett 1983) have experimented with this method. The expert chooses examples and attributes and then inferences are made. Quinlan's method does not however handle probabilistic reasoning.

Research in machine learning has also tried using examples as data from which to extrapolate rules and concepts inductively (for example, Heeffer 1984, Michalski 1983b and the METADENDRAL system)).

Concept mapping is, in one sense, more versatile than other methods in that it allows uninhibited expression of the varied relationships between concepts. This is however, as we have seen, at the expense of syntactic sophistication, binary relations being the only ones allowed. Of course, notations exist for handling complex linguistic constructions graphically. Sowa (Sowa 1984) has a detailed theory of conceptual graphs that does this. However a simple statement like 'Arthur knitted a sweater' would have to be transformed into 'Arthur caused a sweater to move along a path from non-existence to existence' before it could be represented in one of Sowa's conceptual graphs. Semantic networks of this kind are usually non-intuitive formal notations. They are nevertheless required if one wants to represent graphically sentences like the following:

the difference between A and B is C;
if X and Y then Z;
in the seventeenth century artists thought Rubens' painting of
nudes was influenced by his dissipated lifestyle;
the red button must be pressed if the green light is on;
if it's raining or you are cold wear a coat;
the concept of X is central to the domain;
when the lever goes down the arm rotates;
Vernon knows Alf's 'phone-number is ex-directory.

Another problem with a diagrammatic modular representation is that modularising one way always prohibits modularising in

another (is 'Alf's 'phone-number' one concept or two, or sometimes one and sometimes two, or both?). Another point is that different analyses of one domain will identify different concepts. A functional description of a car may deploy different concepts from a structural description and they may be at varying levels of granularity.

Other techniques are preoccupied with eliciting rules. Under this heading I have included interviewing and protocol analysis. Although interviewing between two human beings need have no such limitations, computer implementations of quasi-interviewing techniques have been driven by rule-based production systems and, as a consequence, are dedicated to eliciting rules. This is a pity. Likewise, protocol analysis is associated with human problem-solving which is dependent on procedures and as a result this is the type of knowledge protocol analysis elicits best.

Is there anything wrong in restricting knowledge elicitation to the elicitation of either rules or concepts? After all expert systems are often built on production rules. Kidd (Kidd and Cooper 1985) think that expert system shells can inhibit the user's delivery of knowledge:

...prior to the acquisition process, our understanding of the problem domain was not deep enough for us to make an appropriate judgement on what shell would be suitable. Another problem was that our prior familiarity with AL/X's knowledge structure strongly influenced the type of questions we asked of the expert and therefore biased us to eliciting only those expert rules that fitted into AL/X.

This Procrustean solution is a common hazard. It is also a tempting mistake to conceptualise the system in a maximally efficient way that's out of tune with the expert (Davis and Lenat 1982).

Similar problems occurred in the MOLE medical diagnosis system. Experts couldn't always distinguish between types of objects that the system had chosen for knowledge representation, like observed symptoms and inferred symptoms, or explanatory evidence and tendential evidence. In this respect personal construct theory is preferable as it doesn't create or employ constructs the expert doesn't already use.

Grosz's system TEAM (Grosz 1987) encountered the same problems. The acquisition of different verb forms confounded non-linguists and the acquisition of feature field values confounded naive users. TEAM, however, found it possible to communicate with the user by framing example linguistic constructions for affirmation or denial, for example:

Is it grammatically acceptable to say 'Paris countries',
meaning those countries whose capital is Paris?;
Is it acceptable to say 'Fords', meaning those cars
manufactured by Ford?.

The ASK system (Thompson 1983) also supplies stylised patterns of verb endings to enable the user to compare the new verb with the verb he wants to enter.

Another problem is that the expert's conceptual structures may change over time as a result of the elicitation process. The



knowledge structure once chosen and revealed manipulates the user. Of course this may be advantageous: a half-built system with bugs, for instance, can prompt the expert to give up his secrets.

The elicitation of rules may not be straightforward (Shortliffe 1976). Ramsey (Ramsey et al 1986) says:

...it is often difficult to represent knowledge in terms of rules especially if one already has available descriptive information...rules are not a convenient way to organise knowledge in many domains...Part of the problem is due to the fact that the 'directionality' of production rules can present problems. For example, the rules used in diagnostic rule based systems are typically of the form "IF <manifestations> THEN <cause>". However, much of the knowledge used to create such rules...is descriptive and goes in the opposite direction: if some cause is present then certain manifestations will typically occur.

Moreover some skills that suggest that an underlying set of rules are in operation, prove to be highly 'compiled' or heuristic skills. Whether one believes in heuristic knowledge as something different in kind from other sorts, or just thinks of it as a yet unformalised coincidence of rules, the fact remains that it is not a trivial task to provide a set of rules when one's knowledge is heuristical. Heeffer (Heeffer 1984) found chess masters stumped when asked to identify the relevant features of a chess position that determined their next strategic move. It appears such features are numerous, chunked together somehow and not really available for mental inspection. Heeffer had to do a number of cunning experiments to discover the conceptual grain-size of the features of a chess position. A grand-master's ability to memorise it in

five seconds suggested that he must be seeing large grain patterns of some sort.

But the point is that even in apparently rule-based skills the rule base is often unknown and inaccessible to the expert. One chess player, when asked how many possible moves he would consider at each junction of the game, said "Only one: the right one": hubris or honesty?

The transformation process from declarative knowledge to rules is also an extra overhead for the expert or knowledge engineer in the elicitation process. Gammack and Young (Gammack and Young 1985) agree that

expertise in a technical domain comprises knowledge of more than one kind, not all of which can reasonably be represented in the form of empirical rules.

Also, an expert may not be able to give exceptions to rules unless he sees the system make a mistake with the rules it has already got (McDermott 1980). Sometimes posing counter-examples can help.

Translating from procedural knowledge to declarative knowledge is not much easier either. A meticulous regard for an exact formulation can lead to what a philosopher once called 'the death of a thousand qualifications'. We might call it the 'all-things-being-equal' problem. An algorithm can branch infinitely. A body of declarative propositions, however, must encapsulate all eventualities, constraints and implied rule precedence. This is a difficult task.

Some expert systems accommodate both conceptual and rule-based knowledge. For example, PROSPECTOR (Johnson and Keravnou 1985), the geologists' ore-detecting system, and its knowledge elicitation system KAS, are rule-based but have taxonomies of concepts explicitly represented in the knowledge base. TEIRESIAS (Davis and Lenat 1982) also recognises the distinction between rules and facts:

There are ... two major forms of knowledge representation in use in the performance program:

- 1) the attributes, objects and values which form a vocabulary of domain conceptual primitives, and
- 2) the inference rules expressed in terms of these primitives.

There are correspondingly two forms of knowledge acquisition:

- 1) the acquisition of new primitives - to expand the performance program's vocabulary of concepts, and
- 2) the acquisition of new rules expressed in terms of existing primitives.

Compare also Swartout (Swartout 1983).

[There are] two bodies of knowledge. The first, called the domain model, contains the descriptive facts of the domain... the second body of knowledge, the domain principles, contains the methods and heuristics of the domain - the 'how to' knowledge.

The knowledge acquisition tool KRITON, built on the Loops system from Xerox, uses a combination of tools to elicit both kinds of knowledge. The expert suggests concepts by engaging in forward scenario simulation; repertory grid analysis is performed on them and then they are sorted by laddering and represented in a Loops lattice hierarchy which can support completeness checks since the nodes of the lattice are structured objects with slots. An empty slot or a node floating

apart from the lattice generates a question prompting the user to supply the missing cog or link. Some systems are capable of exposing patterns, groupings and gaps in rules that prompt the expert to fill them, and in TEIRESIAS (Davis and Lenat 1982), diagnostic errors give a context for rule formulation. Consistency checkers are used, for example by EMYCIN, to prompt for clarification and correction.

Procedural knowledge in KRITON is acquired via protocol analysis, partitioned according to pauses and sorted according to domain concepts occurring in them. Diederich admits this is tricky and seems to suggest (compare the KEATS system) that it is largely a text-editing job imposed on the expert who chooses propositions as the antecedents and consequents of the rules, although the system does recognise some lexical items expressing common relations, for example "X is smaller than Y".

Motta (Motta 1986) concludes that knowledge elicitation is not a well defined methodology but a collection of techniques and so the best one can do is to offer a set of tools to perform them. Motta's system KEATS runs on a Symbolics in ZetaLisp and offers facilities for protocol analysis, graphical representation of a domain and knowledge representation and inference. It should be pointed out that these text-editing, graphics and object-oriented programs are part of the Symbolics system and not developed by KEATS. (To digress momentarily it is interesting to speculate to what extent applications of a system can be called innovative. To use a lawnmower as a

lawnmower is not very inventive. It certainly falls short of using a log as a wheel. On the other hand Watt is credited with one of the most brilliant inventions of the industrial age that was more properly a brilliant transformation of a much earlier system. In fact Hero of Alexandria invented the aeolipile.)

The four parts of the KEATS system are a protocol analysis facility: basically a text-editor but allowing segmentation by the user; a graphical sketchpad facility that allows one to 'draw' a domain model that will be represented in the knowledge representation language; an object-oriented knowledge representation language and a production system rule interpreter.

A typical interaction with the system would involve the following. A knowledge engineer records an interview with an expert which is typed into the machine. The knowledge engineer segments this protocol. The conceptual structure that emerges can then be depicted by the knowledge engineer diagrammatically using the graphics facility and this diagram is stored automatically as an hierarchical structure. The production rule interpreter can then be used by the knowledge engineer to model problem solving and run the hierarchical network structure.

Another system comparable to these is KADS (Breuker and Wielinga 1985) which offers a package of different knowledge elicitation methods. Eshelman's system MOLE also combines conceptual and procedural knowledge acquisition, asking the

expert to list relevant objects (for instance, hypotheses and symptoms) of the domain and to draw associations between them, which it then turns into rules.

Gammack and Young's conclusion (Gammack and Young 1985) is a pluralistic one.

...even in a single domain of expertise, the expert's knowledge is of several different kinds. These different kinds of knowledge almost certainly will demand different knowledge elicitation techniques to capture them most effectively.

1.9 An alternative knowledge elicitation system.

We have seen above that concept-based, graphical and rule-based methods of eliciting knowledge all tend to circumscribe the captive sage in the expression of his wisdom. Elicitation of concepts prevents one from discursive elaboration about the domain in general and from giving functional and procedural accounts of it. Elicitation of diagrammatical representations constrains the natural language expression of information and the elicitation of rules imposes an unintuitive burden of translation from declarative facts to rules on the user.

The reason such systems appear to be intractable is, of course, that they are driven by a knowledge representation process that can only trade in artificial constructs and not in the full uninterrupted richness of natural language. Also, it is the primary concern of architects of expert systems to

assemble useful and relevant information. Weiss and Kulikowski (Weiss and Kulikowski 1983) say

A mistake of many novice expert system designers is to dwell on the preliminary knowledge acquisition phase of systems development... One will be overwhelmed with the mass of information, without getting closer to the development of the expert system.

It may be necessary for rapid prototyping to restrict the domain to a sub-domain that is representative, or a set of subtasks that the big tasks are built of.

Davis and Lenat (Davis and Lenat 1982) have similar pragmatic goals.

The knowledge should ... be decomposable into small modular "chunks" that can be expressed with a simple syntax.

But what if it is not? Kosko (Kosko 1986) hits the nail on the head.

The fuzzier the knowledge representation, the easier the knowledge acquisition and the greater the knowledge-source concurrence. But the fuzzier the knowledge, the harder the (symbolic) knowledge processing.

The reason Weizenbaum's system ELIZA is so flexible in accepting natural language is because it doesn't attempt to parse its syntax or represent its semantics but merely pattern-matches key words. One of the two aims of this research is to build a knowledge elicitation program. Is it possible to build a program as approachable as ELIZA that can elicit and store knowledge?

We saw above that the success of such a program depends on the choice of key-words and the choice of responses. The problem is how to make such an elicitation mechanism domain-independent if it has to be triggered by key words? ELIZA is domain-dependent in psychology. One could not really talk to her about how to mend a car (although one might try).

Moreover, to represent the knowledge elicited we would need a parser, grammar and semantics building program. These extra requirements are discussed below. However the first problem is to provide the program with a lexicon and a set of responses that words in this lexicon will generate.

No system can be truly domain-independent since it is situated, like ourselves, in the world. At the very least the boundaries of the world are the boundaries of our domain. This seems to suggest that our system should recognise every word in the language and produce an appropriate response when it does. This is obviously not feasible. What we need for a domain-independent knowledge elicitation system is a lexicon that contains those words that can be deemed to be a common linguistic core across domains and have a common semantics in all those domains, that can be used to produce responses appropriate to all domains.

Thus, just as ELIZA recognises the word 'mother' and invokes a question about families, so we may recognise the word 'under' and invoke questions about spatial relationships, or the word 'think' and invoke questions about human agents. The choice of

lexicon is discussed in Chapter 4.5.

Since this system will perform a type of interviewing we should adhere to some recognised principles of interviewing (Breuker and Wielinga 1983):

- know the domain (or in this case the common core of English) well enough to ask sensible questions;
- know the discourse well enough to ask sensible questions;
- know when to specialise and when to change the subject (asking for justifications at each step can be very off-putting (Grover 1983).)

Since this system also aspires to being domain-independent we should consider criteria of assessment of domain-independence (Grosz 1987) too:

- can it handle all linguistic domains?;
- does it require undue expertise on the part of the user, for example, expertise in systems, linguistics, databases or the current system?;
- how comprehensive is the parser/grammar/lexicon?; can it handle all natural language or only a sub-set or a technical sub-set?;
- to what extent can the user control the dialogue?

Having chosen a suitable lexicon to incorporate into our elicitation program there are a number of different classes of questions that can be generated from the words of that lexicon. Suppose, somewhat improbably, that the propositions volunteered by our domain expert are:

Bosky is a member of Opus Dei.
Bosky wears a biretta.

a) lexical elucidation.

The system can ask questions to supply lexical elucidation , based on its knowledge of the semantic entailments between words (Schubert 1976).

...action predicates as different as "give" and "tell" both involve an agent, an entity directly acted upon..."

For instance, the word 'wear' may generate:

What sort of a garment is a biretta?

Semantic entailments and selection restrictions are commonplace concepts in linguistics as we will see later. They are also by no means innovative in artificial intelligence and expert systems, being variously called integrity constraints or semantic checkers (e.g. UNITS, KAS, AIMDS etc. (Hayes-Roth et al 1983)) and being used for maintaining the integrity of data by checking that the attributes of an object do not conflict with its super-type in a type hierarchy. We, however, are interested in their use as knowledge elicitation devices.

This function of the knowledge elicitation program is discussed in Chapters 6 and 7.

b) spreading activation.

The system can also ask spreading activation questions that concern the whole domain, rather than merely the lexical items

adjacent to the recognised word. For instance the word 'member' may generate the question:

Are there any other members of Opus Dei?

This function of the program is discussed in Chapter 8.

c)inferential.

Another kind of question is the inferential question. This also concerns the whole domain rather than the lexical items of the input and results from the comparison of more than one piece of input.

Do all members of Opus Dei wear birettas?

Another example of a question the system might produce is:

X is Z and Y is Z; how do X and Y differ?

This kind of inferential questioning is exploited by production rule systems that offer truth maintenance and completeness checking. It can be used to eradicate the following problems (Sowa 1984):

- conflict: two rules match the same input data but produce different results;
- redundancy: two rules match the same input data and produce the same results;
- subsumption: one rule matches a subset of the cases matched by a more general rule and the two rules always generate the same result;
- incompleteness: certain combinations of input data are possible but no existing rule matches that combination.

This function of the program is discussed in Chapter 8.

d)conceptual.

Another kind of question is the conceptual one. This might be generated when an unknown word (like 'Bosky') has been used very frequently.

Tell me more about Bosky.

One could exploit the personal construct techniques as well, without the constraint that the grids or ratings impose on them. Dietterich and Michalski (Dietterich and Michalski 1981), in their work on induction, identify 'discriminant' knowledge or knowing those properties that distinguish a set of objects from another fixed set of objects, and 'characteristic' knowledge or knowing those properties that distinguish a set of objects from ALL other sets of objects. Thus our questions may include:

How is X different from Y?;
How is X different from everything else?

This function of the program is discussed in Chapter 8.

As we have seen above, this research has two strands, the enhancement of automated knowledge acquisition and the characterisation of a set of lexical principles.

Thus, there are two main areas of research that inform the current work. One is the field of knowledge elicitation which has been the subject of this chapter. The other is the field of semantics, especially lexical semantics.

Before a detailed exposition of the lexical resolution principles and their role in knowledge elicitation we will look at the field of lexical semantics. This will be the subject of the next chapter.

Chapter 2. Semantics and inference. I.

2.1 Interdisciplinary semantics.

To do justice to a study of lexical semantics one cannot afford to be circumscribed by the confines of one discipline, but is a synthesis of semantic theory possible? A wider question is implied: is a synthesis of disciplines possible? Not to try would be pusillanimous. In Charles Ives' work 'Three Pieces from New England', a number of brass bands, all playing different band music, converge on a town. What is the result? They are all engaged in the same sort of endeavour. Their directions are converging. But is the result cacophony or an integrated whole, albeit to the educated ear alone?

If one were given three texts by, for example, Hume, Piaget and Saussure, on semantics, they would not appear to be different parts of one and the same discourse. One would recognise each discipline as different, even though one had never read these authors before, because of some distinct quality. This quality is not the set of things talked about, for example, concept, sensation, image and meaning. Nor is it the set of questions to which the writers address themselves, for example, what is a concept?; what is the definition of meaning?

The difference seems to lie in the the types of inference deemed valid, the evidence deemed admissible, the answers that are deemed to be answers, the vocabulary, and most of all,

what constitutes a theory for the author we are reading. Variations in vocabulary amongst intellectual groups are predictable. Types of inference vary as well; induction and heuristics in psychology, linguistics and natural sciences; deduction in artificial intelligence, philosophy and formal systems.

Some disciplines scorn empirical evidence; others are founded on its study. Some scholars, predictably from a background of empirical science, discount hypotheses not supported by empirical evidence. Others, from a philosophical tradition, eschew such methodologies. What constitutes an answer or a theory in response to the questions asked is a thorny problem too. To violate the unwritten methodology of one's discipline can provoke scepticism or derision: 'that may be true but is it very interesting?'; 'that is merely a description not a predictive theory'; 'your theory is normative' or 'unfalsifiable' or 'unsupported by empirical evidence'. Even theories of the utmost intellectual rigour may just be of no use outside the discipline they were nurtured in. As Woody Allen said of philosophy, it isn't much use outside the classroom, although perhaps he should have distinguished between philosophical subject matter and philosophical methods.

Another problem is one of style. Sartre's Being and Nothingness contains various mutually contradictory claims which can be overlooked in such a long book. However, that there should be contradictions in six hundred pages is not very

surprising. It is more rewarding to ask oneself why such a work is not necessarily undermined by such flaws. The answer is that rigorously logical thinking does not have the monopoly in the intellectual marketplace and it is pointless to assess everyone in the same light. One would not send a critic of French impressionism to review Tallis's forty part motet.

Another snare is that one is tempted to set up naive dualisms between different kinds of thinkers (Carnap versus the later Wittgenstein for example or Russell versus Strawson) when a moment's thought would suggest that in all probability such writers had a grasp of both sides of the question but chose one avenue only to explore. Russell (Russell 1946) in his History of Western Philosophy takes a similar line. One should adopt an attitude of 'hypothetical sympathy', he says, to the theories of great minds (a recommendation to which he himself pays rather scant regard). This is neither contempt nor reverence because if we are contemptuous we will never manage the feat of imagination necessary to comprehend the theories and if we are reverent we will be blinded to any errors that may come to the surface. Dualisms may only be possible at a higher level: formalism versus natural language philosophy; calculi versus conceptual structures.

2.2 What is required of a linguistic theory?

There are two arms to the current research. One is knowledge acquisition; the other is lexical semantics.

One obvious source (and destination) for a theory of lexical semantics is the field of linguistics. Semantics, a victim of changing fashions, is nevertheless part of the proper study of linguistics.

Before assessing semantic theories per se we should ask what is required of a linguistic theory. For the early Chomsky, linguistics was a branch of cognitive psychology and any grammar needed to have descriptive adequacy; that is, it should have psychological reality for native speakers. Moreover it should have observational adequacy, that is, it would account for all and only the permitted sentences of a language. It should also be exhaustive, consistent and economical.

Gazdar (Sparck-Jones and Wilks 1983) supports this: an adequate formal theory of grammar must permit natural languages qua sets of strings to be generated. It must also permit significant generalisations to be expressed and support semantics, that is, provide the basis on which meaning can be assigned to natural language expressions satisfactorily.

What is a semantic theory? For linguists like Katz it is one that accounts for the following: synonymy, ambiguity, redundancy, entailment, presupposition, superordination,

incompatibility, self-reference and also truth/falsehood by virtue of meaning. Tarski says (Tarski 1944) that such a theory also formulates the conditions under which a sentence of a language may be asserted.

Kempson (Kempson 1977) broadly agrees: the requirements of a semantic theory are that it assign meaning(s) to each word and sentence in the language under consideration. Thus in the case of words it will provide some sort of dictionary and in the case of sentences some set of rules to show the function from word meaning to sentence meaning. This is not straightforward:

contraception is a sin as any fool can plainly see

does not, happily, mean the same as

contraception is a sin as any see can plainly fool.

Moreover, word-order may not only alter the meaning of a sentence but even the meaning of its constituent parts.

Father Blaney has something to do
Father Blaney has to do something

Another requirement of a semantic theory, Kempson claims, is to show how the meanings of words are related to each other, that is, by synonymy, entailment and so on ('man', 'woman', 'child', 'girl' share definitive characteristics in a way 'isard', 'hubris' and 'bradawl' do not). Eikmeyer (Eikmeyer 1981) agrees: a semantic theory should associate expressions with meanings and identify semantic relations (such as hyponymy, meronymy, entailment,

contradiction and co-occurrence in a semantic field) when they occur.

A semantic theory should also generalise over sentences rather than giving an explicit account for each one. This may seem obvious given that, while the total number of words is finite, the total number of sentences is infinite. This is not in the sense that the natural numbers are but in the absence of any rules prohibiting, say, more than ten conjunctions in a sentence.

It seems to me that there is a distinction here. The number
20,192,837,463,029

is not equally conceptually rebarbative as the sentence

I know he knows I know he knows I know he is a left-footer
or even

I dreamt I was a butterfly, a-dreaming it was me

since the incremental nature of numbers gives us a principled way of interpreting them while very recursive or much-conjoined sentences often involve insurmountable problems of interpretation.

Until Chomsky and the birth of transformational grammar and the rise of formal methods, semantics, in linguistics at least, was more a descriptive pursuit than a formal one: semantics but not semantic theory. Indeed, interest in

semantics was minimal in the early days of linguistics. The first stirrings of linguistic analysis in the eighteenth century were in response to perceived structural similarities between languages and in an endeavour to chart the evolution of language change. In the early twentieth century there was a shift of interest to synchronic study of language but only as a descriptive exercise not as a formal analysis. Saussure is considered the father of structuralism which, in its later manifestations, was extended to word meaning although semantics was still an embarrassment to the American structuralist linguists of the 1930s-1960s. Bloomfield (Bloomfield 1946) thought the study of meaning was the weak point in language and would remain so.

The novel approach of Chomsky's generative grammar in the 1950s did not advance semantic theory greatly (this was not his aim) despite his efforts to incorporate a semantic level into his scheme. It is interesting however that here we have perhaps a partial synthesis between the disciplines of linguistics and philosophy, in that transformational grammarians like Chomsky on the one hand and formal semanticists like Russell on the other, independently laid the foundation stones for the subsequent belief that natural language could or should be characterised in a way similar to mathematical or formal languages, with a formal semantics.

It must be remembered, however, that one cannot prove the correctness of any theory, linguistic or not, which

encompasses an infinite range of data since every unobserved case is a potential counter-example.

2.3 Different definitions of meaning.

The aims of linguistic semantics seem unassailable. Discussion of meaning in terms of notions like entailment, synonymy and so on, accords with the assumptions of dictionary writers, and dictionaries are the most commonly used authorities concerning meaning.

One should not overlook however how differently other people have addressed the subject of semantics. Here are some possible definitions of meaning that demonstrate the diverse phenomena that can be marshalled to explain the meaning of words.

The first group of definitions situates meaning in the external world.

- the meaning of a word is supplied by the necessary and sufficient conditions for that word to apply;
- to know the meaning of a sentence is to know under what conditions that sentence would be true (Davidson 1967); we know the meaning of a sentence if we know when it has been falsified (Dummett's theory of meaning);
- the meaning of an expression for a speaker is the sum of situations in which the speaker has heard it (Paul 1909);
- extensionalism: the meaning of a word is the object to which it refers;
- meaning is systematic relations between types of situations (Barwise and Perry 1983);
- meaning is use (later Wittgenstein).

Secondly there are the definitions that anchor meaning within

the head.

- meanings are the mental ideas for which words stand as external signs (Locke);
- meanings are mental images associated with verbal behaviour (early Wittgenstein);
- the meaning of an utterance/sentence is what the hearer/reader thinks you mean (Fay Weldon: you never read what you write);
- behaviourism: meanings are the stimuli that elicit verbal responses; 'the meaning of a sign ...is a dispositional property of the sign where the response, varying with varying attendant circumstances, consists of psychological processes in a hearer and where the stimulus is his hearing of the sign' (Stevenson 1944);
- 'S meant something by X' is (roughly) equivalent to 'S intended the utterance of X to produce some effect in an audience by means of the recognition of this intention' (Grice 1957);
- Strawson's reformulation of Grice: to mean something by X, S must intend: a) S's utterance of X to produce a certain response R in a certain audience A; b) A to recognise S's intention A; c) A's recognition of S's intention (a) to function as at least part of A's reason for A's response R (Strawson 1971);
- the meaning of a word is just what the speaker intends it to mean (Lewis Carroll's Humpty Dumpty) for instance 'glory' means a nice knock-down argument).

Last of all there are the abstract and recursive definitions in terms of language itself that seem quite independent of human beings and the physical world.

- meanings are some kind of eternal archetypes (Plato);
- meaning is 'that set of necessary and sufficient conceptual features that make it possible for the speaker to separate the referential potentiality of any one lexical unit from that of any other unit which might tend to occupy part of the same semantic domain'; 'a meaning is not a thing in itself but only a set of contrastive relations' (Nida 1975) (componential analysis);
- 'the meaning of a word is constituted by its contextual relations' (Cruse 1986);
- the meaning of a word is a semantic field containing all the sentential contexts of the word and all the possible substitutes within those contexts, there being a focal area of the most normal contexts and substitutes (this is the paradigm versus syntagm dualism) (Haas 1964; compare Firth

- 1957);
- the meaning of a word can be known by the company it keeps
(Firth 1957).

Such a proliferation of definitions of meaning fills one with dread. Even more so since our concern here which is lexical meaning seems to play a very minor role in many of the definitions, be they formal or pragmatic ones. We need not founder if we bear in mind that there are really only three places meaning can be found, crudely: in the world, in the head and in the abstract. Thus we are talking about three ontological types: physical objects, mental objects and abstract objects.

In all semantic theories meanings are the progeny of these three to greater or lesser degrees of miscegenation.

Here is a brief outline of the main philosophical positions.

2.4 Meanings in the world. -----

2.5 The referential theory of meaning. -----

Linguists and their forebears have, understandably, in the past if not the present, devoted much time to the study of the meaning of words but of course, alongside them, have been psychologists interested in the meaning of mental objects or

concepts and philosophers concerned with the meaning of meaning, and all these endeavours interleave.

A longstanding philosophical approach is to equate meaning with reference. This is extensionalism or 'the meaning of a word is its relation to the objects to which it refers'. So, proper nouns refer to individuals, common nouns to sets of individuals, verbs to actions, adjectives to properties of individuals and adverbs to properties of actions (Russell 1902).

There are well-known problems in this approach, for instance, in accounting for the different reference of a word when referring to a class, a null class, a specific set or any set, for example:

cleats have many uses
cleats are non-existent now
Biddulph is looking at the cleats
I need at least three dozen cleats

Another problem is that abstract nouns ('happiness'), function words ('and', 'whether', 'in', 'very') and mythical words ('behemoth', 'leviathan') don't seem to have objects of reference.

Of course a totalitarian approach would extirpate all those words like 'behemoth' that were neither logical operators nor had reference. This is the road to logical positivism that a number of thinkers have strayed down over the centuries. Swift, in his 'Gulliver's Travels', satirised Sprat of the

Royal Society by inventing a society where, since words were only allowed to stand for things, people carried the things themselves around with them instead. This policy, designed to eradicate unnecessary floridnesses of style, has the effect, if taken to extremes, of eradicating all that is abstract, poetical, metaphysical and metaphorical. (Kant was in favour of restricting the conceptual machinery of our experience to physical experiences. He believed there to be twelve concepts, not learnt from experience but provided by the understanding, that we apply to it and are indispensable in this regard. However to attempt to apply them to metaphysics is erroneous and speculative metaphysics is a natural error.)

Frege describes a logically perfect language (Frege 1892) where no new sign can be invented unless it has already been secured a reference. Thus, in language, as in mathematics, ontological errors can be avoided.

'The will of the people' can serve as an example; for it is easy to establish that there is at any rate no generally accepted reference for this expression.

It was the absence of reference for the subject of sentences like 'the King of France exists' that led Russell to deny that the meaning of a definite description is the object that it designates. This makes sense really. Definite descriptions seem to be more like properties. A similar linguistic phenomenon is the usage of the word 'is' where 'is' does not imply identity, for example in the English form of words used

to refer to age. We do not suppose that the sentence 'Didier is six years old' expresses an identity relation between two objects: the more appropriate relation is revealed in the French rendering 'Didier a six ans'.

Russell construed the logical form of the sentence 'the King of France exists' as

there is a King of France and no more than one King of France.

This interpretation, of course, as Strawson pointed out, cannot be imposed on 'the lightbulb is broken'. Strawson would rather say that such sentences are neither true nor false in themselves but can be used to make a true or false statement. Incidentally, one has to say that it is easier to make objections to Russell's theory than propose a counter-theory. It is surely the case that once we have established a discourse entity as focus, namely a particular lightbulb, then, for the purposes of our conversation, there is a lightbulb and no more than one lightbulb. Strawson's distinction between referring and saying what we are referring to is harder to counter.

Russell's line of argument forced him to give up the assumption that proper names are names but rather to say (with Frege) that they are 'abbreviated descriptions'. Thus 'Pegasus' would be rendered as 'the winged horse of Greek mythology'. This of course allows the objection that

Pegasus is the winged horse of Greek mythology

can be rewritten after substitution as

the winged horse of Greek mythology is the winged horse of Greek mythology.

This solution also fails to provide a definite description for 'Fred' or 'Ena': there may indeed be many or no set that uniquely picks out the individual.

Others (Kripke 1980; Putnam 1975) have also claimed that the classical view that proper names differ from other concepts in that they have reference but not meaning is incorrect. Thus, it is true just as much for 'peccary' as it is for 'Praise-God Barebones' that its reference is fixed by an initial act of baptism and maintained by the continuous usage of the term.

There are other reasons for abandoning a referential theory of meaning besides the inability of the theory to accommodate logical operators, abstract words and so on. One of the most convincing reasons for this is the philosophical one traceable from the Stoics down to Russell and Husserl. The Stoics distinguished between the sign, the meaning and the external thing or situation referred to by a word, describing the meaning as 'the thing we perceive as subsisting within our thought' or 'what the barbarians do not understand when they hear the Greek words spoken'.

For Husserl, the fact that the phrases 'the victor at Jena' and 'the vanquished at Waterloo' refer to the same man, Napoleon, but have different meanings, conclusively drives an

ontological wedge between meaning and reference. (This is another variation of the substitution objection above.) Another example is the well-known referential equivalence of 'creature with a heart' and 'creature with a kidney', expressions that nevertheless seem to have different meanings. (That two words may have the same intension but different extensions is also a possibility as Putnam demonstrated (Putnam 1973).)

Another problem with the referential theory of meaning (or rather the same substitution problem in another guise) is that, as Frege knew, the verbs 'say', 'hear', 'think', 'conclude', 'perceive', 'know', 'is unaware', 'is surprised' and 'fancy' take complements that cannot be substituted. Quine calls these words 'referentially opaque'. This is true also of modals ('9 is necessarily greater than 7' cannot be rendered as 'the number of planets is necessarily greater than 7') (Quine 1971).

Another problem with the referential theory of meaning is that we may understand the meaning of an expression, say, 'the fattest Catholic priest in Connaught' without knowing the reference. For physical sensations, paradoxically, to know the sense is to know the reference. The proposition

I have got a pain

has not got independent sense and reference.

There are various lines of defence in the face of all these

objections. One is to abandon referential meaning in favour of some mentalist or structuralist theory; another is to modify the referential theory so that it refers not to the external world but to a set of possible worlds which can contain all sorts of objects, for instance, extinct ones, unborn ones, the total class of any object and so on.

Perhaps a referential theory of meaning is a misconception anyway. It is surely no accident that we have two expressions 'means' and 'refers to': they are certainly not interchangeable in the following two sentences.

the name 'Alf Trampleasure' refers to our janitor
gibbous means pregnant

2.6 Truth conditional semantics.

It is clear, from the above concern that referential semantics be truth-preserving, that the referential theory of meaning is closely bound up with truth conditional semantics, an idea that comes from the ancient Greeks. The basic terminology for discussing language was developed by the Greeks and adapted by the Romans. Plato, and then Aristotle, distinguished between onoma (subject) and rhema (predicate). For Aristotle, a noun plus a verb made up a complete thought, and this notion pervaded mediaeval grammar studies. For example, for Petrus Hispanus (Pope John XXI) the noun and verb were the main parts of the sentence, the rest being syncategorematic. Aristotle had made the same distinction between onoma, rhema and

syndesmoi. (Incidentally, it is claimed that Hispanus also identified adjectives, proper names and definite descriptions, and distinguished between intension and extension, object language and meta-language, universal, existential and indexical statements, and between paradigmatic and syntagmatic choice. The building that he built to study in collapsed and killed him: an unfortunate end for an architect of linguistic theory.)

Truth conditional semantics, as Aristotle pointed out in his *Metaphysics*, operates not at the level of the word but at the level of the sentence.

An onoma or rhema by itself [roughly, a subject or a predicate] resembles a concept that is neither combined nor disjoined. Such is 'man', for example, or 'white' if pronounced without addition. As yet it is not true or false.

To say of what is that it is not, or of what is not that it is is false, while to say of what is that it is, or of what is not that it is not, is true.

Aristotle's views on semantics were also adopted by Leibniz, Frege and the early Wittgenstein among others. Indeed, right up to the present day there persists a strong disinclination in philosophy to separate the studies of meaning and truth (for example, Blackburn 1984). Truth conditional semantics is important but there is a lot more to the meaning of words than this, in the form of lexicography, etymology, philology and lexical relations. Clouds of dust rise from the page at the mention of certain of these rather nineteenth-century concepts

and philosophers and formal semanticists are uncomfortable discussing them. It is not clear why this is so and one aim of this research is to show that a rigorous and principled approach to lexical semantics is possible.

Suffice it to say, for most philosophers of language, the relation between meaning and truth is the one that most occupied their thoughts. Wittgenstein's *Tractatus* looked for a logical form that encapsulated logical relationships and the inferences from a proposition. This theory of meaning was elaborated in the logician Tarski's (Tarski 1944) theory of truth which stated that a sentence *S* is true if and only if *P*, where *S* is the name of that sentence and *P* the set of conditions which guarantee the truth of that sentence, for example, 'snow is white' if and only if snow is white. Tarski's theory cannot contain its own truth predicate because of the existence of paradoxical sentences. Kripke's solution is to allow such paradoxical sentences to fall into truth value gaps (Fitting 1986).

Tarski's theory of truth is not adequate though. As Kempson (Kempson 1977) points out, it may be contingently true that the sky is blue if and only if the sun is shining but we would not want to say that the one is a specification of the meaning of the other; compare also 'snow is white' if and only if grass is green.

Another problem with truth-conditional semantics is that we may not be happy with the two-valued logic that it is based on.

Russell and Strawson, as we have seen above, took issue on this subject when considering sentences like

the King of France is bald

(Russell 1902; Strawson 1950). Russell, to ascertain its truth value would decompose it into the concatenation of a number of propositions and if they were all true the sentence was true otherwise it was false. The situation described by the original sentence did not obtain at the time and thus was false.

For Frege and Strawson (Strawson 1950), however, this conclusion is meaningless for the very reason that there was no King of France at that time. The existence of the King of France is a presupposition. Presuppositions, unlike entailments, follow from a sentence whether it is true or false. If we believe that a theory of meaning is defined in terms of entailment then there is no place in this theory for presuppositions. Of course the problem is that if we accept this idea of presupposition our original sentence is neither true nor false and cannot be dealt with by two-valued logic.

Not only noun phrases have presuppositions; verbs like 'regret' and 'realise' presuppose the truth of the thing regretted or realised as they do also when preceded by a negative. This, as Kempson points out however, suggests that one cannot logically deny the proposition in the same sentence. However, consider

- 1 Vernon regretted eating Bim's pie
- 2 Vernon didn't regret eating Bim's pie
- 3 Vernon didn't regret eating Bim's pie because he hadn't eaten it

Most people would be happy with 3 which implies either that there is another type of negation (external as opposed to internal negation; denial of a previous assertion as opposed to negative description) under which presuppositions are not maintained or that we should abandon the idea of presupposition and talk only of entailment. Gazdar (Gazdar 1979) identifies seven kinds of presuppositional construction.

- 1 the man who ate it should pay up (definite description)
- 2 Fons regrets that Ponce suffered the bastinado (factive)
- 3 George has stopped doing it (aspectual)
- 4 Emily managed to disguise it (implicative)
- 5 the dog has defiled the pergola again (iterative)
- 6 it was the lord-lieutenant who won the knitted pilch (cleft)
- 7 what the housemaster ate was my india rubber (pseudo-cleft)

Another problem with presupposition is what happens in the conjunction of two propositions if the presupposition of one is what is being asserted in the other, for example

Vernon is married and his wife has a road haulage company

Suppose Vernon is not married. Then the second conjunct is neither true nor false, according to Strawson and Frege, while the first conjunct is definitely false. How would we build a truth table for 'and' under these circumstances, or indeed any of the other logical operators? What are the semantic rules that pair a sentence with its truth conditions?

Quine has argued (Quine 1953) that the terms analytic truth,

meaning, definition and synonymy are interdefineable and so it is vacuous to try and explain any of them in terms of any other. Moreover, he claims that the analytic/synthetic distinction is mistaken. Others disagree (Fodor, Bever and Garrett 1974) that while the total number of analytic sentences may be small and all too familiarly dreary they do exist by virtue of the properties of language, for example,

if Vernon is a bachelor then he is not a married man
if Vernon kissed Vera then Vera was kissed by Vernon

Kempson points out too that circularity is inevitable in self-contained systems like mathematics and logic, as Quine seems to allow (Quine 1960 but see also 1953).

Truth conditional semantics per se equates meaning with the logical form of a sentence and this theory of meaning enables one to make logical inferences only. However, there is obviously more to meaning than this, not just in terms of analytic but also synthetic inferences. Componential theories of meaning make inferences as a result of lexical decomposition that cannot be made merely on the basis of logical form. This distinction is crucial and accounts for the curious inability to communicate between logicians and linguists on the subject of semantics. For logicians entailment is a logical relation (example 1); for linguists it can be a semantic one as well (example 2).

1 Vernon is a plumber and Vernon uses a molewrench
Vernon uses a molewrench

2 Arthur is a widower
Arthur had a wife

There is a middle ground between these extremes, governed by new and extended logics, that would account for

Socrates is a man and all men are mortal therefore Socrates is mortal (predicate calculus);
Arthur knows he is a curmudgeon therefore he is a curmudgeon (epistemic logic);
if it is raining then it is possible that it is raining (modal logic)

and so on. However, broadly speaking, the two domains of formal semantics and lexical semantics do not make comfortable bedfellows. Kempson is happy to define synonymy as mutual entailment but this in itself does not give us a procedure for detecting synonyms unless we can independently establish entailments.

Another problem with truth conditional semantics is its inability to give a full account of the semantics of non-indicative sentences: questions, commands, performative utterances ('I name this ship Podsnap') and so on. Aristotle knew this to be true. Like Protagoras, he recognised various sentence types including, interestingly, the question, statement, command and prayer and suggested that, for example, a prayer has neither truth nor falsity.

There are also a large number of function words that are deemed not to affect the truth conditions of a sentence like 'even', 'really' and so on that are nevertheless not quite semantically empty. Aristotle identified Greek particles as

expressions that 'do not have meaning [that is, referential meaning] but link those that do'.

We should also remember that the truth or falsity of a sentence is not necessarily the most important thing about it. This is not only true of various kinds of speech act ('well that was a clever thing to do, to go to Didsbury without a waterproof') but also of poetic or aesthetic pieces of language. As Frege says (Frege 1892) of epic poems:

The question of truth would cause us to abandon
aesthetic delight for an attitude of scientific
investigation...it is a matter of no concern
to us whether the name 'Odysseus' ...has
reference.....

This is not only true of the aesthetic and poetic. If I state the proposition

opposite my window is an old man in a coral pink jumper climbing the steps to a house and a girl in a Saxe blue vest walking by eating a Cornish pasty

the reader has no means of verifying the claim which incidentally is no longer true. But who cares? One thing is certain. The reader does not need to ascertain the truth of the proposition before constructing a mental concept or image or reflecting on the intra-sentential lexical relations. Nor would the image be abruptly extinguished on discovering that I had lied. Indeed, it is sometimes forgotten that (except for certain acts of faith) we have to understand the meaning of something before we can say whether it is true or not.

However, this position of Frege's misses the point. Whether my proposition about the Cornish pasty is true or not is indeed irrelevant but that does not undermine the fact that to know its meaning we must know what state of affairs would have to obtain for it to be true.

Another problem with truth-conditional semantics is that it may also seem unintuitive that the reference of a sentence is its truth value giving all true sentences the same reference and obliterating all that is specific to a particular true sentence.

One of the most uncomfortable discrepancies between classical logic and the semantics of natural language is the law of the excluded middle, *tertium non datur*, P or not P . Once, when I was working in a shop, an American boy came up, pointed at the cash register and said: 'Is that a washing machine or something?' When I said it wasn't he replied 'But everything is a washing machine or something.' Thus classical logic, P or not P , made a brief and inappropriate appearance. However, one does not need to have very conservative tendencies to cling on to this above all axioms. This is not only because to abandon it causes one's truth tables to disintegrate, but because it takes the extension principle with it and opens the door to non-monotonicity.

However, there are numerous occasions on which we would want to say, in response to a question, 'yes and no' or 'it is and it isn't'. It is not possible to say whether a newspaper is

black, yes or no. It is and it isn't. The mistaken belief that a property must apply throughout, to a plenum, rather than to differentiated parts, allows the following amongst other expressions: 'his work is both good and original, but the parts that are original are not good and the parts that are good are not original'. Not everything is as undifferentiated as the curate's egg no doubt was.

In conversation with the linguist David Cram on the laws of proverbial logic he argued that the logic of proverbs and saws is quite different from classical logic. 'You can't tell a book by its cover' and 'the apparel oft proclaims the man' seem to suggest the axiom P and not P , when taken together.

It is also non-intuitive to say that not not P implies P . Problems such as this inspired intuitionistic logicians to develop an alternative to classical logic without the axiom P or not P . Here, in every situation, every statement is either true or fails to be true. Something that fails to be true can become true but not vice versa. Thus everything that is intuitionistically provable is classically valid.

Entailment from negation is a thorny problem. 'I don't dislike Bevis' as we have seen does not entail 'I like Bevis'. This is an interesting phenomenon and is related to the idea of oppositeness. It is well known that we do not call things opposites unless they share a common dimension. They must be opposites on some axis (for example, 'hot' and 'cold' on the axis of 'heat') (Cruse 1986). Mere remoteness of concepts ('bow

tie' and 'truculence' for example) is not a sufficient condition for us to call them opposites. Negation however does not constrain us to any particular semantic axis. If something is not hot this does not mean it is cold. We may be talking about a piece of music or something of which heat is not a property.

If someone says 'I don't know what I am accused of', does he mean he doesn't know if it is P or Q or that he hasn't a clue which of all the laws on the statute book he is accused of? Negation doesn't commit itself. We can get round this in a dialogue system by asking the user to be specific of course. 'I dislike Fred' unilaterally but not mutually entails 'I do not like Fred'. 'I like Fred' unilaterally but not mutually entails 'I do not dislike Fred'. Lyons discusses a taxonomy of oppositeness relations (Lyons 1977).

Entailment from negation in sentences can of course be very complicated. Consider the possible entailments from the following sentence fragment.

it wasn't that the house master with the wall eye said that the boy had abused the swimming pool

We cannot tell what exactly is being negated here.

It is clear that language is vaguer and more ambivalent than logic.

Truth conditional semantics is useful in characterising synonymy or, what Cruse calls, cognitive synonymy (Cruse

1986). Synonymy is a lexical relation of antiquity among other rhetorical devices observed by the Sophist Prodicus. Cognitive synonyms, according to Cruse, have to be syntactically identical and yield the same truth conditions when substituted for one another. Cruse suggests 'fiddle' and 'violin'. Sentences that are identical except for the replacement of words by their cognitive synonyms, stand in mutual entailment to one another.

Synonymy might conceivably be a useful relation for knowledge elicitation purposes. If, for the sake of argument, one believed that 'is a subordinate of' is a synonym of 'is a member of' then any inferences that one could make from the first could also be made from the second.

Some synonyms are only partial which makes this more difficult, for example,

I almost killed him; I practically killed him;
we're almost there; we're practically there.

The trouble is that to exclude all partial synonyms would probably leave us with none.

Other synonyms are bound by syntactic constraints only and so can be considered synonymous for semantic purposes, for example,

go and hide; *go and conceal;
I have finished; *I have completed.

It is the flexibility of words and their shifting strata of

semantic traits that makes the characterisation of synonymy so difficult. Substitution without change of meaning is not enough. For example 'my father has got brown eyes' can undergo successful substitution and become 'my parent has got brown eyes' but one would not say that 'parent' and 'father' are synonyms. Substitution in both directions is required.

Some synonymy is vague. Some synonyms are better than others: 'sofa'-'couch' are possibly better than 'dirty'-'soiled' (Cruse 1986). One might think it was to do with the number of semantic traits two words shared. Cruse shows this is not so. 'Spaniel' and 'alsatian' share many but are not synonyms or near-synonyms. There has to be a concomitant decrease in contrastiveness.

There are various definitions of synonymy: having identical contextual relations (Cruse 1986), having identical meanings, being identical on all relevant dimensions of meaning (Lyons 1981). Applying such criteria reveals the rarity of true synonyms. Fortunately for knowledge elicitation purposes such theoretic niceties are largely superfluous. It may be that recorded differences do not have any effect on entailment which is our main concern here. For instance, 'munch' and 'chew', though good candidates, are not substitutable in 'John was chewing gum'. However most of the entailments we might make from 'munch' are entailments from 'chew' too, for instance there is an animate agent, a mouth is involved and so on. Many differences appear to be merely differences of convention.

Semantic nuances are difficult to identify, for example,

he looks almost Chinese
he looks nearly Chinese.

One can see the oddity while being reassured that entailment is the same from 'nearly' and 'almost'. It could be argued that identical entailments are a criterion of synonymy.

In any event however, we should not expect a lot from a study of synonymy when so many words have subtly different senses, for example,

I am about to build a chapelle ardente
I am about to throw up

I met my wife in Paris
I met the Vicar in Safeways

A synonym is required to share all the senses of the word in question.

Plesionyms, or words that differ very slightly in meaning and do not preserve truth but yield sentences with different truth conditions, are really more common than synonyms, for example, foggy-misty; fearless-brave; pretty-handsome. In other words you can assert one and deny the other.

Synonymy is rare as one might expect from the plurality of the real world despite frequent claims of identity. Of course one would not construe such claims as ones of numerical identity but even qualitative identity is rare despite peculiar claims one comes across.

this cot is identical to the Rosalind cot you ordered but has been substituted due to unavailability

It is not clear what this claims except almost-identity.

It is odd that synonymy has excited such attention from linguists, being often quoted as one of the phenomena a good linguistic theory must account for. The virtual non-existence of synonyms, except when taken from different linguistic registers ('begin', 'commence'), perhaps suggests that it is of more marginal interest than is believed and should be put away with other dusty linguistic beasts like zeugma, synecdoche and the rest.

Thus, another projected use of truth conditional semantics, to underwrite synonymy, seems rather vacuous. It seems that those linguistic phenomena that can be encompassed by the referential theory of meaning and truth conditional semantics are of a dry, logical or objective kind and the shifting subtleties of lexical semantics perpetually elude them.

2.7 Performative semantics.

Referential and truth conditional semantics place meanings 'out there' in the world. There are many other theories that also explain meaning in terms of real things such as physical objects, situations, utterances, actions and so on. I call the following theories performative for want of a better blanket term to describe the theory of meaning as use, the main proponents of which are Grice (Grice 1975), Austin (Austin 1940) and Searle (Searle 1969). As Austin (Austin 1940) says:

It may justly be urged that, properly speaking, what alone has meaning is a sentence... We say 'look up a word in the dictionary' but words and phrases have meaning only in the sense that there are sentences in which they occur....You might think... that you could ask: 'What is the meaning of a word?', i.e. a word in general, any word, no particular word. This is spurious. It is like saying: 'What is the meaning of X?' when X is uninstantiated. Its the philosophical fallacy of asking about Nothing-In-Particular.

Perhaps this is partly true: it is certainly hazardous to try and use abstract words one has discovered in a dictionary ('degringolade') without a few contextual authorities. I don't really feel this is true of concrete ones though. Having discovered that 'spraynts' means otter-dung I feel fairly sure I could use the word correctly if I ever came across any to talk about.

For Austin, concepts and abstract ideas are fictitious entities but most people still think there is something that is the meaning of a word. Hampshire believes that there is not one

meaning of a word but that the meaning of a word is a class of 'similar particular ideas'. Austin, however, says that this class is just as fictitious an entity as a concept or abstract idea. Morris says that 'a meaning' is not 'simply located' somewhere that can be referred to without the total activity of 'semiosis', but then he goes on to talk of the 'designatum' of a word which is a kind or class of object. Austin says that this is as fictitious an entity as a Platonic idea.

Austin (Austin 1940) claimed some utterances were obviously not just descriptions of events (for example, 'I promise to stew the windfalls'). The meaning of such utterances is not best characterised by reference or truth conditions but by the function or use to which the utterance is put, the action it performs and the presuppositions inherent in it. Thus, an utterance's meaning may be to insult, inform, warn and so on. The theory is more complex than this. Suppose I say 'I promise to return your tam o' shanter'. There are three acts going on, according to Austin: the locutionary act of just uttering the sentence (voicing those six words); the illocutionary act (actually making a promise thereby, not just referring to one) and the perlocutionary act (getting the hearer to respond, for example, by lending the tam o' shanter).

Thus, a logical, lexical or truth conditional analysis of the utterance is somehow missing the main point of what such an utterance means. (Kempson points out, however, that a truth-conditional account may be possible; it's just that, for

example, making a promise is part of its own truth condition (Kempson 1977)).

One cannot be entirely happy with this analysis. It seems stretching a point to say that someone's ulterior motives in uttering a sentence (purloining someone else's tam o' shanter) are part of the meaning of that utterance. On the other hand the theory is really the only explanation of certain wry and ironic comments. There is no doubt that the sentence 'Oh you're here' is of little descriptive import and short on information as people usually know that they are immanent (compare the SDP's vacuous slogan 'the time is now'). Thus Austin (compare Searle 1969) says the question is not one of the truth value of an utterance but its appropriateness according to certain conditions (that have sadly to be painstakingly enumerated).

An observation by Putnam (Putnam 1973) seems to support the 'meaning as use' school of thought. It is surely a fact that many of us use words in good faith without any formal verification method or lexical safety net but just because they have worked for us before and have a conventional usage.

everyone to whom the word gold is important for
any reason has to acquire the word 'gold';
but he does not have to acquire the method of
recognising whether something is or is not gold.

Such a task is accomplished by the division of linguistic labour.

One is always tempted to generalise from a good theory. Thus the performative semanticists, although their theory is restricted to the spoken word, tried to extend it to all utterances, not just ones that were obviously self-referential events of the 'I-name-this-ship' variety, or non-indicative utterances. We will see below that more modern theories of semantics (situation semantics) have also felt the need to invoke the context of use and the situation of utterance to characterise meaning but it seems eccentric to reject lexical and referential information when it has an obvious bearing on the meaning of a word.

The desire for parsimony, to develop a general-purpose semantics, does tempt us to abandon common sense even when it serves our purpose well. The fact that behemoths don't exist doesn't mean a referential account of the meaning of the word 'bucket' is useless. The fact that buckets exist doesn't mean an ideational account of the meaning of the word 'centaur' is useless either. Hume, Locke and others (Hume 1739, Locke 1690) considered that the only explanation of the thoughts 'centaur', 'unicorn', 'golden mountain' and other, perhaps fanciful, ideas, came from a combination of a number of impressions that referential objects like 'man', 'horse' and 'golden' gave rise to.

Thus, there is a danger that, in spreading a performative theory of utterances to cover all language, the theory becomes very thin indeed. It also seems to drive an unnecessary wedge

between spoken and written language. Any text that is not written in the first person is fairly inaccessible to a semantic account like this yet it is potentially equally comprehensible to a native speaker as the utterances of his fellow countrymen are. He doesn't have to wear different interpretative hats for spoken and written language.

It may be that implicatures or just ellipsis ('The time [most suitable for David Owen to be elected] is now') provide as good an explanation as speech-act theory. At the end of the day speech-act theory does not give a satisfactory account of the intrinsic meaning of words which seems to be what makes all kinds of discourse comprehensible to speakers of the language.

A more hopeful development of this theory is to replace an analysis of meaning by an analysis of the conditions for the appropriate use of words and sentences (Fillmore and Langendoen 1971). Thus, (if it is possible to enumerate such a set of conditions at all without coming to the conclusion that every sentence is multiply ambiguous) we may draw on the external world ('that bucket'), speaker's presuppositions ('my son is a plumber' presupposes I have a son), hyponymic entailment ('my son is a plumber' entails I am a mother), speaker's intention ('I promise to return the drain-rods' effects a promissory speech-act) and so on.

Such a powerful procedure is difficult to gainsay. One thing must be said. Formalising such a theory would be difficult. The logical flavour of words like 'entail' may suggest to us

that such a theory is merely a common sense extension of truth-conditional semantics and logical form. However, the conjunction 'but' is an indicator of pragmatic implicature, for example 'my brother is a plumber but he suffers from hydrophobia' implies that most plumbers are sanguine about water. In logical form 'but' would be replaced by the 'and' connective and the implicature is lost. It is not a trivial task to define a formalism that would render the sentence complete with all its attendant presuppositions.

Also, Kempson (Kempson 1977) points out that such a theory doesn't intermesh with transformational grammar. A semantics of use would be associated with the performance level rather than semantics of logical form that is associated with competence at the level of deep structure. One is uneasy about the increasing chasm between sentence meaning and utterance meaning that this theory forces us towards, although this may be unavoidable.

From the consideration of meaning as use, it is a short step to theories of communication. If some utterances are only explicable in terms of some function that they have in a conversation ('Oh you're here') then perhaps this is the key to a thorough-going account of all utterances and even written language. The best known contribution to a theory of communication is that of Grice (Grice 1975).

As we saw above, Grice attempts to give a principled account of why people say things. The theory is based on the implicit

subordination of interlocutors to the Cooperative Principle which embodies constraints on what one normally has regard to in a conversation, for example, quantity, quality, relevance, perspicuity, clarity, brevity and so on. The theory is that, if the Principle is flouted in a manner obvious to both parties, then it is being flouted with some other purpose in mind that is itself compatible with the Cooperative Principle. Such collusive violations are called conversational implicatures and convey some kind of meta-meaning over and above the intrinsic meaning of the sentence, a meta-meaning which is not predictable from that sentence but peculiar to the participants in the situation of utterance.

The first thing to say is that the theory is normative not predictive or deductive (Grice 1975).

Since to calculate a conversational implicature is to calculate what has to be supposed in order to preserve the supposition that the Cooperative Principle has been observed, and since there may be various possible specific explanations, a list of which may be open, the conversational implicature in such cases will be a disjunction of such specific explanations; and if the list of these is open the implicature will have just the kind of indeterminacy that many actual implicatures do in fact seem to possess.

This seems to be more realistic than Gazdar (Gazdar 1979):

because indeterminacy is hard to handle formally
I shall mostly ignore it... a fuller
treatment of implicature would not be guilty
of this omission which is really only
defensible on formal grounds.

As Rieger warns (Rieger 1981), we should not seek to 'make imprecise phenomena precise in order to render them accessible

to exact analysis'.

Theories of meaning as convention, which include both performative and pragmatic theories, have interested philosophers since Plato and the ancient Greeks. In the Socratic dialogue *Cratylus*, the debate concerns the source of language as convention or the physical world. The *physis-nomos* dispute concerned whether there is a natural connection between the shape of words and what they stand for. Aristotle says

an onoma signifies this or that by convention.
No sound is by nature an onoma: it becomes one by
becoming a symbol.

However this is a long way from the meaning of whole sentences being a matter of convention, or is it? In his later work Wittgenstein abandoned a picture theory of meaning for a theory of language as use or language as a tool or game with which to effect communication. Harris (Harris 1990) believes that Wittgenstein (in his post-*Tractatus* philosophy) and Saussure (in his posthumously published lectures) shared a view of how language works as a rule-governed game. For Saussure this conclusion was linked with his belief that the value of words was derived from other words rather than from a one-to-one correlation with extra-linguistic entities. Likewise, Wittgenstein believed that the meaning of a word was its use, not some object for which it stood as a surrogate. Both compared words with pieces in a game of chess.

This, incidentally, has some similarities with game theoretic

semantics. Game theory is a mathematical theory dealing with game-like situations in which participants wish to maximise some property from a position of uncertainty with respect to the state of nature and the actions of other players. This involves predicting another's actions and predictions. It has been applied to semantics by Hintikka and others (Hintikka 1975). Game theoretic semantics is similar to Dummett's theory of meaning (Dummett 1976). The meaning of a sentence

links the content of an assertion with the commitment that a speaker undertakes in making that assertion; an assertion is a kind of gamble that the speaker will not be proved wrong.

Kempson suggests that performative and pragmatic theories of language can be assimilated into a Chomskian model if it is allowed that they are theories of performance that do not militate with semantic theory at the level of competence. It is not clear what this claim amounts to. Unless the transformation rules are explicitly formulated then presumably no theory of performance would be incompatible with any theory of competence. It is not clear what value there is in trying to coerce language use conventions into a formal structure. It is at any rate hard to give a purely semantic explanation of why I say 'Is that your hat in the bath?' if I really mean 'Recover your hat from the bath'.

2.8 Formal semantics.

Under the heading 'meanings in the world' I would include

formal semantics (pace Frege and his followers, who believed either that meanings were 'graspable' abstracts or mental intensions), since formal semantics, or more precisely model theory, characterises meanings in terms of models or possible worlds.

Formal semantics is the interpretation of a formal language, that is, a means of assigning truth-values to the sentences of that language or systematically linking a formal language with a semantic universe or domain of discourse. There are three important notions: a precisely defined language, a semantic universe and a function that maps each well-formed formula of the language onto its meaning in the semantic universe.

Montague semantics is the main formal semantic development in linguistics. It was born of Montague's initial conviction that formal and natural languages are fundamentally the same, in that they give the meaning of a sentence by connecting it to the world. (This can be contrasted with the linguistic semanticists Katz, Jackendoff and Lakoff, who give the meaning of a sentence by translating it into another language.)

Montague semantics is built on categorial grammar but goes beyond it, translating the syntactic structures of English into intensional logic and then giving them a set-theoretic semantic interpretation. Model theory is a branch of mathematical logic that studies the properties of formal systems via their models, through set-theoretic interpretations as opposed to proof-theory. Thus we can see

from the outset that the chief concern of one of the main branches of formal semantics is not lexical semantics but logical semantics as revealed by the syntax of natural language.

Categorial grammar, on which Montague semantics is built, has its roots in the discipline of philosophy but since then it has been taken up in many guises by philosophers, namely formal semanticists like Montague, Lewis and Cresswell, linguists and computational linguists.

Husserl (Reichl 1982) wanted an a priori universal grammar which specified the laws covering the combination of meaningful elements. The idea is that (as in the discussion of grammatical functions) the meaningfulness of a sentence such as 'this tree is green' doesn't depend solely on the meaning of its individual components but rather on the possibility to see it as an instance of the schema 'this S is P' where S and P are meaning categories standing for nominal and adjectival. He wanted to assign categories to words according to functional substitutability, specify which combinations of categories are possible and state laws for assigning categories to those combinations.

As extended by Ajdukiewicz (Ajdukiewicz 1935), and still, broadly speaking, today, the theory specifies two basic categories, the sentence S and the name N. Derived categories are built out of these, for example, an intransitive verb like 'sneezes' is defined as requiring an N (for example 'Vernon')

as an argument in order to become an S (that is 'Vernon sneezes'). The category of 'sneezes' under certain variants of categorial grammar would thus be $N \backslash S$ or 'something looking backwards for a noun to become a sentence', directionality being required to exclude 'sneezes Vernon'. The idea when parsing is to cancel out.

Saumjan's (Reichl 1982) version of categorial grammar handled lexical decomposition too (for example 'autumnal' is derived by applying a function to 'autumn') and also case grammar (for example, the agentive 'runner' is derived by applying a function to the verb 'run'). He also had categories denoting aspect, tense, mood, causatives, diminutives and so on.

Long distance dependencies are the main challenge for any grammar. This theory is open to the same objections as phrase structure grammars in that it is restricted to surface structures (it cannot handle 'Birkin wrapped the cleats up') unless other techniques of analysis than straightforward cancelling-out are adopted.

Categorial grammar follows the strong competence hypothesis of Bresnan, namely that there should be a direct correspondence between the rules of grammar and the rules of processing.

Current theories of categorial grammar attempt to show that the cancellation process can be applied incrementally to an input string and that at any point there will be a semantic interpretation for what has been consumed so far, rather in

the way that we jump to semantic conclusions in real life. It seems likely however, that we invoke far more world and lexical knowledge in pruning possible parses than is available in the lexicon of a simple categorial grammar. Moreover, categorial grammar categories may be intended to, but do not always, parallel semantic types, nor do combination rules always parallel semantic operations. Also, despite the intuitive appeal of an incremental theory as opposed to one involving deep structure, it does have trouble with simple sentences like 'Vernon ate the porridge quickly' since the sentence has been cancelled out completely before the word 'quickly' has been reached, requiring a new cancellation to be carried out.

Steedman's solution to this is to add functional composition as a combination rule, based on the combinators of Curry and Feys. The combinators can be considered as the semantics of the language. They define abstraction without bound variables which are computationally expensive to keep track of (for example, LISP). Type-raising can allow a purely left-branching analysis for an English sentence. The problem is that such rules are too powerful, allowing far too many cancellations. If one is concerned, as Steedman is, with psychological reality, one might equally easily come to a different conclusion, that is, not that we parse and interpret incrementally but that we can hold partial information and synthesise it at the earliest sensible opportunity.

The simplicity of a theory that could build a syntactic and a

semantic representation incrementally as humans do is tempting. A number of grammars have been built on these lines despite some unprincipled fudges required to parse left to right. The potential of categorial grammar has been exploited by a number of theories in formal semantics, for example Montague grammar.

Montague grammar has a sophisticated machinery for semantics incorporating lambda-abstraction, meaning postulates, higher order quantification, intension and extension operators and a model theoretic interpretation. Since Montague it has been recognised that expressions of the typed lambda calculus provide an excellent means of expressing the semantics of language whose syntax is analysed using categorial grammar. This is because categorial grammar uses the syntactic equivalent of function application in many of its rules.

The order of operation of the rules in Montague grammar is of crucial semantic significance. For each syntactic rule there is a unique corresponding semantic interpretation rule. It is a powerful tool to use in conjunction with syntax as it obviates the need for various operations in the syntax such as quantifier movement, NP movement or deletion and co-ordination reduction transformations. This appeals to advocates of context-free phrase structure grammars like Gazdar (Sparck-Jones and Wilks 1983) although problems remain such as the binding of pronouns in dislocated constituents and the nesting of equative and comparative clauses.

Montague grammar is built on intensional logic. By intension is meant, according to Frege, sense or meaning, as opposed to extension which is denotation or reference. We saw above when discussing philosophical theories of meaning that we must reluctantly abandon the meaning as reference theory ('Pierre thinks Londres is great' does not entail 'Pierre thinks London is great'; 'Vernon wins' is extensional but 'the person who gets the most points wins' is intensional).

What is the intension then of, say, a name? The answer, according to Montague, is that it is a concept. Likewise the intension of a predicate is a property and the intension of a declarative sentence is a proposition. The extension of a name, on the other hand, is an individual; the extension of a predicate is the class of individuals to which it applies and the extension of a sentence is a truth-value.

Part of Montague's definition of intensional logic is his semantics. Its purpose is to correlate the meaningful expressions of the language to their denotata. The denotation of an entity expression is an individual. The denotation of a sentence is a truth value. The denotation of an expression of type b/a is a function with the denotation of a as argument and the denotation of b as value. The denotation of an expression of the type a/s (that is, a function that's looking for a sense to give an a) is the denotation of the expression of type a under all possible circumstances, that is, the set of possible denotations is a function with the set of all possible

worlds as argument and the set of denotations of a as value.

So, what is claimed is that the semantic structure mirrors the syntactic structure and that model-theoretic semantics is adequate for natural language analysis. This can only be partially true however since an analysis of parts of speech in terms of their logical or set-theoretic function leaves untouched the whole realm of lexical semantics, let alone connotative and pragmatic meaning.

The traditional view of language is that the distinctions between parts of speech correspond to distinctions in denotation: nouns denote people, places and things, adjectives denote properties, verbs denote actions or states. This is not as straightforward as it seems however. Nouns as well as verbs can denote actions ('the journey of the Magi'); nouns as well as adjectives can denote properties ('a curch of linen').

It is possible to extend Montague semantics to include other factors. For instance, for Lewis, intensions are functions whose values are extensions and whose arguments are indices where an index is an 8-tuple of co-ordinates, namely, possible world, time, place, speaker, audience, indicated object, previous discourse, assignment. Lexical semantics are, to all intents and purposes however, omitted, being included merely as a cursory adjunct in the form of some meaning postulates.

Possible world semantics has its origins in Leibniz (see also Wittgenstein's possible states of affairs) and is an attempt to

get round the problems of representing the meaning of those sentences that are not true in one model, say the world at this moment, but would be true if the world were slightly different, that is, the way it was yesterday or could logically be tomorrow. For Carnap, a possible world for a logical calculus S would be a class of sentences in S which contained, for every atomic sentence, either that sentence or its negation, but not both, and no other sentences. Such a class of sentences gives a complete description of a possible state of the universe of individuals with respect to all properties and relations expressed by predicates of the system.

For Cresswell, a possible world is any subset of the set of all space-time points. For Lewis, a possible world is a possible totality of facts determinate in all respects. Lewis' system is a complicated system designed to handle, respectively, ordinary model theory, tense, spatial deixis, first person pronouns, second person pronouns, anaphoric pronouns, discourse deixis and the domain of variables. Its complexity suggests situation semantics.

2.9 Situation semantics.

Another theory that places meaning (largely) 'out there' in the world is situation semantics. This idea is not new although not previously formalised. For example, for Malinowski (Malinowski 1960) and Firth (Firth 1957) and the London school of linguistics, meaning was a relation between the components

of the situation, namely people, their verbal and non-verbal actions, objects, events and effects. Thus, situation semantics attempts to invest model theory with psychological realism, not by enhancing the lexical component but by replacing possible worlds with human situations.

Nida (Nida 1962) took up this idea using the notion of environments, namely the objective and subjective environments but also, of course, linguistically, there are the contextual and structural environments. The formal characterisation of contexts (closely bound up with the frame problem) is a pressing problem recognised by others (Eikmeyer 1981):

contexts... should be given by appropriate context=description which would have to be as detailed as possible in every relevant respect...As far as we can see nobody has provided yet a workable solution for determining the relevant properties of contexts in a non-adhoc way.

It is possible situation semantics can be reformulated as simple model-theoretic semantics but including speaker and hearer as part of the model, thus refining and qualifying further the possible meanings of an utterance. The important distinction situation semantics makes is between two sentences that describe the same situation but carry different information: 'the linguistic meaning of an expression greatly underdetermines its interpretation on a particular occasion of use' (Barwise and Perry 1983). One can draw analogies here with the later Wittgenstein's notion of 'language as use'. Model theory (and its natural heirs) and Wittgensteinian

philosophy have been polarised because the latter was dubbed pragmatic when it was a rude word. Now a reunion is possible (Wittgenstein 1958):

what must be added to the dead signs [i.e. the orthography] in order to make a live proposition is something immaterial, with properties different from all mere signs. But if we had to name anything which is the life of the sign, we should have to say that it was its use.

For Barwise meaning is 'systematic relations between types of situations'. For Cooper (Cooper 1987) it is 'a relation between utterance situations and described situations'.

To measure meaning by changes of information states seems odd; because X makes all sorts of inferences and acquires new information from what you tell him, it does not mean that that information was somehow conveyed by your utterance. There is a difference between giving someone money and enabling them to make money. They may make more money than you had in the first place! Another point must be made, namely, that written discourse is not incoherent, yet the significance of 'speaker', 'hearer' and 'situation' are minimised if not, on occasion, absent. What X means does not equal what X entails ('that cloud means rain'). One must have some sympathy with this line however. One does not utter every proposition that is true but only those that are significant at the time: significance and meaning intersect.

The approach is especially helpful when dealing with proper names. The sentence 'Humphrey sneezed' may depend heavily

for its reference on the speaker and context of utterance. This is not necessarily true however. I may indeed be referring to my doctor Humphrey, a fact only my friends and interlocutors may know. On the other hand I might be writing and append the explanation, 'the winner of the cracker-eating competition at Uppingham School on July 1st 1914'.

One difference between situation theory and model theory is that situations are partial: they do not support all the facts that obtain at a given location in time and space. Cooper's motivation is a desire to build a theory that will help explain the nature of information processing by humans and machines and provide an underlying theory for natural language semantics.

Situation theory incorporates the notion of semantic appropriateness where situation types can be custom-built to prohibit such sentences as 'Humphrey smiles' where Humphrey is a dog or 'running kissed Anna' if we so wish. Cooper does acknowledge the problem that we may always want to meaningfully assert the negative of these sentences, for example,

Humphrey didn't smile because he's a dog and they don't and so on. We may feel that any kind of prohibitive schema is oppressive and a theory of semantic precedence would be more helpful.

Some computer programs have been written to handle situations

or temporal contexts. The idea of situations is inherent in Isard's noughts and crosses program (Isard 1974). Utterance situation is like the context index in Montague Grammar. The described situation is a portion or chunk of the real world. This notion is comparable to a possible world.

It is claimed (Cooper 1987) that situation semantics provides an economic method of disambiguation namely by context, and also the representation of opaque contexts.

Situation semantics may be the obvious way to treat indexicals too. Perry (Perry 1979) suggests that one can think of sentences like 'I am making a mess' not as a true statement with a missing reference but a proposition that is true or false only 'at a person'.

One feels inclined to object that situation semantics pays disproportionate regard to conversational utterances rather than written text. If the theory claims that semantic elucidation depends on the situation of utterance it is hard to see how text is ever understood at all. Context is certainly relevant and one can argue that a word never has exactly the same meaning in any two contexts. However the efficiency of any code rests on the obliteration of extraneous differences in order to signal semantic contexts (Nida 1975). If text is comprehensible, as it surely is, then perhaps contextual theories have developed out of all proportion to the phenomena that they intend to account for.

2.10 Behaviourism.

A linguistic movement that anticipated performative semantics was behaviourism. Behaviourism comes in various guises, all of them treating meaning as implicit or explicit response. Neither treatment is altogether convincing. If meaning were explicit response, then this would entail that no response meant no meaning. To say meaning is implicit response is to claim something that is unverifiable. This theory clearly belongs under the heading 'meaning in the world' but seems far removed from lexical meaning or the idea of meaning as found in a dictionary.

For Austin, the answer to the question 'why did X say what he said?' is an indicator of meaning. For the 'forties behaviourists, for example Bloomfield, a similar appeal is made to context. The question is not 'what is referred to?', 'what ideal model could this sentence be mapped on to?', 'what conceptual/mental model could this sentence be mapped to?', 'what are the truth conditions of this sentence?' or 'what is a componential analysis of this sentence?' but 'in what situations would this sentence be uttered?'. We can see that Austin's performative semantics echoes this commonsense pragmatic attack on meaning. As Russell points out (Russell 1946) deductive thinking from self-evident (or not so self-evident) truths had given way to scientific inductivism. Thus, empiricists in linguistics tried to analyse language as any other empirical phenomenon by an analysis of the situations

in which it occurred.

The main difference between the behaviourists and the performative semanticists is one of intention. While they both reject the analysis of language as a logical calculus, for Austin and his fellow thinkers the speaker's intention is part of the characterisation of meaning while for the behaviourists language is like any other empirical epiphenomenon such as smoke and its meaning is the situation under which it occurs, a situation being speaker's stimulus + utterance + hearer's response. Thus, the meaning of the word would be that set of features common to all the situations in which the word was uttered.

This seems to us now a crude theory in that the speaker's stimulus may be all kind of bodily functions that can not properly be said to be part of the meaning of the words he uses. Likewise, one of the most powerful properties of language is that we can refer to objects that aren't around ('the cleats are in Leighton Buzzard') but should not be excluded from an account of meaning merely for that reason. Bloomfield, begging the question, calls this 'displaced speech'.

Behaviourism has links with logical positivism which Bloomfield embraced in the journal *Language* 1933. This doctrine is possibly the most chilling in its expression and consequences of any in the field of language. It is the natural heir to the empiricist philosophy of Hume, Mill and Russell. In logical positivism there are only two kinds of legitimate and

meaningful statements, namely:

the logically verifiable (e.g. P or not P);
the empirically verifiable (that is, reports of simple sense data, verifiable by immediate experience).

Carnap, one of the early exponents in this field, in 'The Logical Syntax of Language' of 1937, says

all empirical statements can be expressed in a single language, which is the language of physics.

The idea was that ordinary language was confusing and one should construct an ideal artificial language, and translate into it. Everything, except analytic and mathematical truths and empirical observations, would be demonstrably meaningless. This, as Strawson pointed out, glosses over problems of translation. How can you translate from natural language if you do not know what it means? If you do, why is the translation necessary (Strawson 1963)? Incidentally, ordinary language philosophers, like Wittgenstein, Ryle and Austin, also believed that natural language was too unruly to be systematised but Ryle and Austin pursued a reverent and painstaking philological course of study that was the antithesis of that of logical positivists like Ayer.

It is clear from the above examination of theories of meaning 'in the world' that we are no nearer a principled lexical semantics, but rather that language has been stripped of its lexical dimension by the different Procrustean formalisms into which it has been squeezed.

2.11 Meanings in the head.

We now turn to those theories of meaning that place meaning 'in the head'. This may seem rather confusing since under any theory apprehension of meaning must be a mental process: we map words onto physical objects using our mental faculties and we construct in our heads abstract meanings for words recursively out of other words. Surely all meaning is in the head.

However, for certain thinkers, it is the peculiar subjective experience itself, associated with a particular word, that constitutes the meaning of that word, as opposed to any ratiocinative process that we engage in when construing a word.

2.12 Image theory.

Referential problems with behemoths led some philosophers, and many other people in their wake, to the image theory of meaning or 'the meaning of a word is explained in terms of an image in the mind of the speaker'. The theory has its groundings in Aristotle who claimed that

words are spoken symbols or signs of affections or impressions of the soul, written words are signs of words spoken. As writing, so also speech is not the same for all races of men. But the mental affections themselves, of which these words are primarily signs, are the same for the whole of mankind, as are also the objects of which those affections are representations or likenesses, images, copies.

For Locke most ideas are not innate but acquired by experience (Locke 1690):

the senses at first let in particular ideas, and furnish the yet empty cabinet, and the mind by degrees growing familiar with some of them, they are lodged in the memory and name got to them. Afterwards the mind proceeding further abstracts them and by degrees learns the use of general names. In this manner the mind comes to be furnished with ideas and language, the materials about which to exercise its discursive faculty.

Of course the rationalist picture was quite different. Descartes, (compare Kant above) extrapolating too much perhaps from the epiphany with the bent stick in the puddle, says (Haldane 1955):

...any man who rightly observes the limitations of the senses and what precisely it is that can penetrate through this medium to our faculty of thinking must needs admit that no ideas of things in the shape in which we envisage them by thought are presented to us by the senses. So much so that in our ideas there is nothing which was not innate in the mind.....

It is true that we may need some kind of innate capacity to carve up the undifferentiated plenum of sensory experience into discrete objects. Functionality is the same: the set of railings beyond my window is, at one and the same time, a fortification, an optical device for splitting up the buildings beyond into visual strips of equal width and so on.

Plato of course also believed we did not learn concepts but 'remember', like clouds of glory, previously acquired forms.

Kant, in The Critique of Pure Reason, while he agreed with the

empiricists that there cannot be innate ideas in the sense of anything known prior to any sense experience, was not prepared to say that all knowledge must be derived from experience. The apparatus of, on the one hand, human sensibility (that is, perception, or the senses) and, on the other hand, the understanding (that is, abstract thought) might have a form or structure that moulds our experience (Kant 1781):

through the former, objects are given to us;
through the latter they are thought...
the order and regularity in objects which we
entitle nature we ourselves introduce. The
understanding is itself the lawgiver of nature.

Sensory snapshots are not the primary data: to perceive them at all requires prior knowledge of an objective world.

Mentalism is a natural home for those foxed by the non-referential meaning of words like 'behemoth'. They are not out there so they must be in the head. The trouble is, this theory has its own problems. As Wittgenstein realised, a mental snapshot of a man climbing uphill would look just like a man sliding down; a fat man would resemble a pregnant one, and so on.

Also, we might be able to manage one picture for an expression like 'Richard Nixon' but it is not reasonable to expect this. He does after all look different on every occasion and from every angle and under every light. It is equally difficult to imagine one picture of a chair or a triangle (right-angled?; equilateral?). Locke (Locke 1690) says:

the idea of a triangle must be neither equilateral, equicrural, nor scalenon but all or none of these at once.

The picture of an animal-in-general is unimaginable as well (Berkeley 1710):

The constituent parts of the abstract idea of animal are body, life, sense and spontaneous motion, By body is meant body without any particular shape or figure, there being no one shape or figure common to all animals, without covering whether of hair or feathers or scales etc. nor yet naked; hair, feathers, scales and nakedness being the distinguishing properties of particular animals and for that reason left out of the abstract idea. Upon the same account the spontaneous motion must be neither walking, nor flying, nor creeping; it is nevertheless a motion, but what that motion is, it is not easy to conceive.

It is not clear what picture words like 'virtue' inspire either.

Two expressions may have the same picture as well ('the victor at Jena' and 'the vanquished at Waterloo') without our wanting to say they mean the same or are synonymous. Likewise one expression may have two associated images without us wanting to draw the conclusion that it is ambiguous. As with extensionalism some words don't seem to have associated images ('and', 'almost') yet are not meaningless.

Disciples of this theory die hard though and it is not surprising since we have expressions like 'I can see it in my mind's eye', 'I see what you mean' and so on. Mill and Berkeley tried to salvage the notion by suggesting that an

image or idea could represent an abstract or complex idea if attention was somehow attracted to the essential attributes and withheld from those that are accidental. This might help with 'triangle': perhaps we see a fleeting triangularish shape with three angles. The traditional objection is that this is an image not of a triangle but of a fleeting triangularish... and so on. This seems a bit unfair. To concentrate on one thing is not make any judgments about the presence or absence of other things. To imagine a party where there happened to be no women is not the same as to imagine a stag party. Blackburn (Blackburn 1984) has a point though when he says that the logical conclusion of this theory is that, if you cannot imagine a bed without a member of the opposite sex in it, then that is a concept the meaning of which you do not know.

Another objection by Wittgenstein is that we just do not operate in this way. When we recognise a flower as being red, this is not because we have compared it to a patch of red in our minds; this would be to embark on a *degringolade* to a *reductio ad absurdum*. It also seems to imply that any image-making device, for instance a cheval glass standing in the Gobi desert, would be a thinker.

An example of a thinker who has taken up the image theory to extravagant lengths is Titchener (Titchener 1909):

meaning is the blue-grey tip of a kind of scoop...
cow is a longish rectangle with a certain
facial expression, a sort of exaggerated pout.

Another problem is that of self predication, one of the premises of Plato's theory of forms, or roughly speaking, the form F has the property f, thus the form of green would be green. This however is implausible in conceptual terms. Is the concept of green green? Is the set of green things green? As Santayana said: 'loveliness is not lovely; it's even better!'.

Over and above these problems, the essentially subjective nature of this as a theory (my pictures may be different from yours) should undermine communication, yet there must be a sufficient consensus about meaning to make communication possible. To say images are not necessarily pictures leaves us wondering what they are instead.

This theory gives us a simple mechanism compared to the heterogeneous ones needed to underpin the pragmatic theories but is not susceptible to symbolic representation and inference which a semantic theory requires. Nor, despite Titchener's valiant efforts, does it succeed in defining the large army of non-pictorial abstract words, still less in giving an account of general lexical relationships such as synonymy, oppositeness, hyponymy and so forth that a semantic theory seems to require.

As a philosophical position this semantic theory informed the work of the early Wittgenstein (Wittgenstein 1921) although his picture theory of meaning is more obscure, atomic propositions being somehow pictures of atomic facts in a not merely conventional way but one of real correspondence, as

paintings correspond to reality or musical notation to music. (Incidentally the latter notion is one to conjure with. The 'top' line of a stave is the one usually highest when a musical score is held in the hand and thus could be said to correspond to a 'high' note. But what is 'high' or 'low' about a note exactly? It seems very little except perhaps the posture of the singer who sings it but this has only a metaphorical isomorphism with the 'altitude' of the note he sings.) Wittgenstein later abandoned this position and indeed some believe (Harris 1990) it to be spectacularly naive and a theory linguists had long since abandoned.

It is understandable that the non-identity of sense and reference should lead one to think of meanings as some kind of concept. To think of them as mental entities however is a kind of psychologism that Frege, for one, rejected. It seemed more likely to him that meanings were public property, some kind of abstract entity that can be 'grasped' by different people and the same person at different times. Frege agreed that someone's idea of a word is a mental image arising from memories of sense impressions, being saturated with feeling and private to an individual. However, he thought of a sign's sense as being common property transmittable from one generation to the next.

The notion that the extension of a term can be determined by a concept in the head is rebutted by Putnam (Putnam 1973) since extensions are partly determined socially by the linguistic

community (the division of linguistic labour) and partly indexically: as Kripke's notion of rigid designators suggests, if we discover that water is H₂O then nothing but H₂O can properly thereafter be called water. We might caution mentalists as Burke cautioned revolutionaries: 'the nature of things is a sturdy adversary'.

There is incidentally a veritable choir of literary voices who can only be heard faintly in this thesis, who reject the characterisation of word meaning in terms of mental images or at any rate lament the impossibility of matching any words and thoughts exactly. For Shelley, words are only an approximation of a poet's thoughts (Defense of Poetry) although he says of the Creator ('Prometheus Unbound'): 'He gave man speech and speech created thought which is the measure of the universe'.

Incidentally, the linguistic determinists in anthropology believe the semantic character of the form classes (that is, the parts of speech in English) fixes the conception of reality in a language community, and that differences on this level correspond to different Weltanschauungen. This doesn't tell us which came first of course: is 'justice' a noun because it is perceived to have thing-like qualities or vice versa?

The priority of thought over speech does seem to lend some support to the image theory of meaning. Nelson and others have evidence that children can sort cars and planes into different groups before they have acquired the corresponding words. Fodor believed that since children and

animals appeared to be able to think before they could speak that there must be a primary language of thought (Fodor et al 1975) and that the word 'boy' was a convenient one-word abbreviation for 'young' + 'male' + 'human' and so on, primitives which we afterwards 'forget'. Sampson (Sampson 1980) objects that, on the contrary, there are no Wordsworthian clouds of glory: we know the word 'boy' before the words 'male' and so on. 'Sibling' is arguably more primitive than 'brother' or 'sister' but much less familiar. Here is a fairly awful poem by the nineteenth century poet Frederick Locker that expresses the Fodorian sentiment.

A Terrible Infant

I recollect a nurse call'd Ann,
Who carried me about the grass
And one fine day a fine young man
Came up and kiss'd the pretty lass.
She did not make the least objection!
 Thinks I, "Aha!"
When I can talk I'll tell Mamma"
-And that's my earliest recollection.

Edmund Gosse had a similar recollection, reputedly of a time before he could speak, of a dog stealing a piece of meat from the table.

However, a large number of men of letters seem to believe in some kind of unbridgeable chasm between thoughts and words. Trollope in his Barchester Towers regretfully acknowledged that there was no daguerrotyper for the writer: word paintings are at best an interpretation, at worst a travesty of the mental image. In a lovely passage of Jean Paul Sartre's, the writer

describes the attempted recall of a day at the seaside. With every recollection, one more sensation was replaced by a word. 'Beach' rather than 'shore' or 'sand' or no word at all fixed the reality in a certain way. After many years of recollection of this particular day every sensation had been replaced by a word and the original experience was lost to him for ever.

It is also sometimes true that ideas can be expressed more pungently by implicit references than blatant ones. Lawrence's largely autobiographical work Sons and Lovers culminates with an act of euthanasia. Such a word or concept is never however expressed; it is probably true that Lawrence would not have advocated it explicitly. What then is being described? It seems that rather than the meaning of words being 'in the head', on the contrary there is a discrepancy between what we can think and do and what we can express in words.

Chapter 3. Semantics and inference II.

3.1 Meanings in the abstract.

Since accounts of meaning in the world and meaning in the head have largely failed to address the question of lexical semantics we turn now to a consideration of meaning 'in the abstract'.

3.2 Structuralism.

Structuralism provides a natural home for those retreating from the problems of a mentalism that involves one-to-one mapping with words and images. Extensionalism can account for concrete words ('bucket') but is not so good for words with mythical referents ('behemoth'). A mentalist image-theory can handle some abstract words quite well but is not so good at others like 'question'. What is a question if it is not an object or an image? We all know what a question is and answer the question by providing a definition in terms of other simpler words, or a 'meaning in the abstract'.

This is an over-simplification of structuralism of course, but suffice it to say that from invoking the external world to explain meaning many scholars in both linguistics and literary theory have withdrawn into the symbolic world to provide an essentially recursive explanation of language in terms of itself. Saussure (Saussure 1916) says

Language is a system of interdependent terms in which the value of each term results solely from the simultaneous presence of others.

While we may question the total context-dependence of word meaning (whether the context is a sentence or the language itself), nevertheless such an approach seems to hold more promise for lexical semantics than the theories of meaning in the world and meaning in the head described earlier do on their own.

Structuralism has groundings in lexicography, that is in dictionaries that attempt to identify features and legitimate noun-adjective combinations and also dictionaries of synonyms, antonyms and so on. One can compare Lyons' and Cruse's work in this area and the lexicographical tradition of onomastics or arranging vocabulary according to meaning groups.

One of the origins of structuralism is field theory as developed by Trier in the 'thirties after Humboldt and Saussure.

Saussure adopted the 'semiological' approach to communication which generalised from the code model of language to all other forms of communication (Saussure 1916):

Language is a system of signs that express ideas and is therefore comparable to a system of writing, the alphabet of deaf-mutes, symbolic rites, polite formulas, military signals etc....
A science that studies the life of signs within society is conceivable...

Todorov suggests this has its origins in Augustine who

approached the study of grammar, logic, rhetoric and hermeneutics within the unifying framework of a theory of signs. Systems of signs governed tropes, gestures, religious rites and sacred texts. Modern day semiotics has not fulfilled expectations. Trier, however, applied Saussure's notion of language as a system to the study of vocabulary, and thought of synchronic vocabulary ranged according to content in fields placed hierarchically or adjacently. Each unit is delimited with respect to its neighbours.

Structuralism is properly a linguistic movement rather than a philosophical one, being concerned not so much with the metaphysical nature of meaning itself as with the analysis of the meaning of particular words, among other things.

Structural semantics has been one of the main trends of European linguistics since the nineteen thirties, although unpopular in the 'sixties and 'seventies along with lexical semantics.

One can distinguish two lines of thought in linguistic semantics, namely, North American structuralism in the wake of Bloomfield and also a line from Sapir and Whorf to the ethnolinguists. Bloomfield and his followers were hostile towards the study of meaning which was an obstacle to the scientific approach of a mechanistic behaviourist because it seemed to require having a scientifically accurate knowledge of everything in the speaker's world (Bloomfield 1946).

Bloch and Trager likewise eliminated lexical meaning from

linguistic analysis and Harris (Harris 1963) substituted for semantics the description of language according to distribution: the difference between 'life' and 'rife' lay solely in distribution.

So, lexical meaning was sacrificed to a scientific ideal. (A similar fate befell the mind amongst members of the philosophical mind-brain identity school: the chosen methodology could not handle the concept of mind except by reducing it to a different and tractable substance, namely brain.)

Bloomfieldians tended to equate meaning with the thing-meant or with a situation and the responses to it (Bloomfield 1946). A more accommodating approach to the idea of semantics was born with Nida's article (Nida 1951) 'A system for the description of semantic elements' which introduced a proper terminology for semantics. Words like 'meaning' and 'mentalist' were restored to North American respectability and Bloomfieldianism was undermined by generative linguistics.

Descriptive semantics' other line of descent is anthropology or ethnolinguistics and its concern for the vocabulary of kinship relations, disease names and so on (Wallace and Atkins 1960). It is striking how similar ethno-linguistic componential analysis is to modern European structural semantics. Lounsbury (Lounsbury 1964), for example, regards the system of kinship terms as a semantic field or paradigm or set of forms which all have a common or 'root' feature but all differ in respect of

other features or 'semantic dimensions'. Each term can be defined componentially as a bundle of features; this definition is the expression of a term's significatum.

The most recent developments in semantics have been termed structural. We should distinguish at this point between two kinds of structuralism: field theory and componential analysis. Coseriu distinguishes three sorts of structural semantics (Coseriu and Geckeler 1981):

- 1 the configuration of associations of one sign with other signs in the vocabulary (semantic fields);
- 2 disambiguation or the assigning of forms to meanings; transformational grammar as first conceived by Katz and Fodor (Katz and Fodor 1963; Katz 1966) has this approach (semantics of logical form);
- 3 the analysis of functional lexical oppositions; decomposition into smaller elements or features (componential analysis).

Weisgerber, in the nineteen sixties, distinguished between differently configured lexical fields, for example, the series (for example, fail-pass-credit-distinction), hierarchies (for instance, kinship terms) and multistratified fields (for example, the linguistic articulation of dying in German for people, animals, plants, objective and subjective attitudes and so on). He distinguished between fields in natural phenomena, material culture and intellectual life.

Lyons (Lyons 1968) also sought to identify lexical systems (or lexical fields) according to paradigmatic and syntagmatic sense-relations. By sense relations Lyons means synonymy, hyponymy (unilateral implication, say, 'scarlet-red'),

incompatibility (for example, 'red' and 'blue'), complementary opposites or tertium non datur (say, 'single'-'married'), antonymous opposites (say, 'big'-'small'), converse opposites (say, 'husband'-'wife'). (Note, this is not the same as compositional analysis of the insides of words themselves. Lyons rejects this (Lyons 1963).)

Incidentally, one must distinguish between this type of field and the concept of a semantic field as used to describe all the uses of one word and the relationship between all the dictionary entries for that word.

In psychology, Osgood (Osgood et al 1957) tried to measure meanings by semantic differentiation or the 'successive allocation of a concept to a point in the multidimensional semantic space by selection from among a set of given scaled semantic alternatives'. Coseriu dismisses this as connotative and based on hearer reaction. This seems a little harsh: if one is to take psychology seriously at all one must acknowledge the value of empirical evidence as well as the results of disciplines with different methodologies. The distinction between connotative and denotative meaning is not so sharp anyway that one can afford to dismiss such methods of elicitation.

Coseriu objects that connotative meaning is extralinguistic but does not offer a method of distinguishing where connotation ends and inherent meaning begins. One might more truthfully say that connotative meaning is very hard to formalise or

elucidate. One might turn to another discipline like philosophy or poetry for some elaboration of this and other vague kinds of meaning although not all linguists would accept the 'explanations' volunteered by the Romantics and Coleridge (who coined the term 'esemplasy' for the unifying power of the imagination). Sperber (Sperber 1986) objects that they

deal with vagueness in vague terms, with metaphors in metaphorical terms, and use the term 'meaning' so broadly that it becomes quite meaningless.

It is interesting to note in passing that non-scientific explanations are often in this day and age deemed by (quasi-)scientists to have no explanatory power at all. Coseriu's objection is less devastating. He merely claims connotative meaning is extra-linguistic. He also suggests that Pottier's componential analysis of types of seat in terms of features like 'having a back', 'having four legs' and so on is extra-linguistic too and not an analysis of linguistic content.

I think this is probably evidence that, in the analysis of physical objects particularly, meaning is very close to denotation, despite Coseriu's distaste for this conclusion. Complex concepts such as 'probation officer' or 'rancour' may be more susceptible to linguistic analysis but chairs and tables are typically things identified deictically not analytically. Coseriu dodges concepts like 'chairs', however, and makes much of essentially subjective concepts like 'warm'. However, he rejects the labelling of them as subjective and

imprecise because, as a structuralist, the word-object mapping and its relative precision is not his concern: linguistic content is defined in terms of linguistic opposition and not in terms of real objects and the relations between them.

Coseriu argues that if you can't tell whether something is a goat or a sheep this does not show the concept is nebulous; on the contrary it shows that you have a clear grasp of the concepts but reality is vague. Buying shoes is always much harder when you know exactly what you want.

The denotative/connotative distinction is a well-known one, denotative semantics concerning referential meaning or the relation between words in the language and objects in the world. The connotative aspect of words on the other hand concerns structural meaning or the relations between words and other words. Denotative semantics is not vague enough; connotative semantics is not formal enough, but to arbitrarily discount the latter would be unthinkable in other branches of intellectual thought. Here in passing is Burke's opinion in *The Sublime and the Beautiful* (Pittock 1980):

Words, especially abstract words, have no direct, denotative meaning: ...the power and prestige they acquire in society comes largely as a result of their uncertain connotative meaning. It is precisely because we have no clear image of the heroic that we admire heroes. What we can define is diminished thereby, in semantics as in politics. In both, Burke believed, connotative context lent authority, just as the Sublime operated in the connotative context of human awe and terror.

Lexical field theory developed into componential analysis

which is an approach to semantics that has been heavily exploited by linguists and computational linguists. It represents a systematic attempt to analyse lexical meaning as opposed to logical meaning and to give an account of words other than logical operators.

However, before we embark on lexical decomposition there are problems characterising lexical fields. It is clear that the members of a lexical field are somehow related ('auntie', 'brother', 'cousin'; 'angry', 'calm', 'pleased') but the grouping of words into fields is too vague as a formal characterisation of meaning.

Again, there are so-called function words that do not generate a field or trigger conceptual networks ('and', 'before', 'or'). Kempson (Kempson 1977) attempts a definition, suggesting that a lexical field is a network of items related by hyponymy and incompatibility.

Coseriu (Coseriu and Geckeler 1981) argues that field theory is descriptive but lacks a method. The oppositional principle isn't explicitly defined; the distinction between linguistic delimitation and extra-linguistic delimitation is muddled and undue use is made of technical terminology (say, military ranks) and not enough of non-technical language.

Coseriu thinks the distinction between objects and language is crucial and that technical vocabulary is deceptive because it is structured according to objects and not on the basis of

language. It seems true that in the creation of technical terminology we have more regard for precise, clearly demarcated concepts that can be subjected to logical, mathematical or set-theoretic analysis and which have a regular in-built structure.

It is also true that we beg the question about the inherent structures of language if we are only prepared to adduce those word-fields we have self-consciously constructed according to a plan. (This is why translation of technical language is artificially easy compared to ordinary language.) It seems appropriate to eliminate such terminology and nomenclature from this research since one of the main assumptions of the work is that linguistic analysis is most productively carried out on non-technical terms.

What can we make of these wide and varied contributions to lexical semantics? One thing is clear: while there is evidence of a more systematic approach than is apparent in descriptive linguistics, nevertheless no general transcendent semantic principles seem to emerge, nor are there any formal methods for dealing with unruly lexical data.

It should be pointed out that post-structuralist thought, perhaps pusillanimously, deems significations or meanings to be essentially unstable anyway and not to have the discrete nature of sheep that enables them to be herded into a lexical field (Selden 1985):

The sign is not so much a unit with two sides as a momentary fix between two moving layers. The dictionary confirms only the relentless deferment of meaning: not only do we find for every signifier several signifieds (a 'crib' signifies a manger, a child's bed...) but each of the signifieds becomes yet another signifier which can be traced in the dictionary with its own array of signifieds ('bed' signifies a place for sleeping, a garden plot...). The process continues interminably, as the signifiers lead a chameleon-like existence, changing their colours with each new context.

3.3 Componential analysis.

It is tempting to think that closer inspection of lexical fields would reveal some structure or schema that we could apply to all words as a framework for lexical semantics.

It is clear that one avenue to take at this point is to say that there must be common denominators that are shared by words in a lexical field and that a definition of each of the words in the field in terms of simpler words would reveal the building blocks of meaning.

The notion of viewing complex concepts as generated by simple ones has a long history (Mill 1843):

The laws of the phenomena of the mind are sometimes analogous to mechanical, but sometimes also to chemical laws. When many impressions or ideas are operating in the mind together, there sometimes takes place a process of a kind similar to chemical combination. When impressions have been so often experienced in conjunction, that each of them calls up readily and instantaneously the ideas of the whole group, those ideas sometimes melt and coalesce into one another, and appear not several ideas but one...These are cases of mental chemistry; in which it is possible to say that the simple ideas

generate, rather than that they compose, the complex ones.

This seems to suggest that (at least some) words might undergo a similar analysis.

While Mill distinguishes between generation of words from atoms and the composition of words, nevertheless, the guiding force behind methods such as this is an atomic reading of the universe, favoured by various people from Democritus to Newton and Leibniz, and culminating in a pervasive atomism in modern thinking since Frege. It is apparent in artificial intelligence, formal semantics, critical theory (structuralism and post-structuralism) and arguably in politics, Thatcherite conservatism being essentially scientific rather than humane, levying taxes per capita and treating the individual as atomic whether he be the survivor in an enterprise culture or the victim of social Darwinism.

Leibniz, and other seventeenth century philosophers, laid the foundations for an atomistic semantics. Leibniz sought a world of uniquely independent language constants. As Russell (Russell 1946) puts it,

[he] cherished the hope of discovering a kind of generalised mathematics which he called *Characteristica Universalis*, by means of which thinking could be replaced by calculation. 'If we had it' he says 'we should be able to reason in metaphysics and morals in much the same way as geometry and analysis.'

An atomistic approach to language gave rise to componential analysis. One exponent was Hjelmslev (1963) who thought that

the content level of language could be analysed, for example, ram = he-sheep and so on. The idea is the familiar one that an unlimited number of words can be made up of a limited number of primitive irreducible elements. You swap a primitive element and you get a new word. This exchange test is similar to the commutation test of Heyse in the 1950's who measured differences in content in terms of features.

European componential analysis also has its American counterpart in Weinrich (Weinrich 1966) and Bendix (Bendix 1969):

a minimal definition of meaning is that set of semantic components that are sufficient to distinguish the meaning paradigmatically from the meanings of all other forms in the language.

Nida (Nida 1975) believed a componential analysis of words was possible. To analyse a concrete term (say, 'hoe'),

- find a superordinate (say, agricultural implement);
- find the hyponyms (say, 'Dutch hoe');
- compare with co-hyponyms (say, 'fork');
- list the componential features (say, 'tool', 'hand-held');
- form the definition.

To analyse an abstract term (say, 'beautiful'),

- find words that overlap in meaning (say, 'lovely');
- determine the range of things that can and can't be qualified by the related meanings (for instance, 'pretty man' and 'handsome lake' are unorthodox);
- spot contrasts between the related meanings (say, 'lovely lady', 'beautiful lady');
- list the significant features of 'beautiful'.

Componential analysis is not of course as simple as this. Any

definition of language in terms of simpler language must eventually hit bottom: the level of semantic primitives, atoms, features, sememes: call them what you will. The ontological status of these elements is fair game for sceptics. Either they are words of the same status as those words they are used to define or they are another sort of beast. In either case they themselves are susceptible to semantic investigation. A componential semanticist may be forced to accept that they are irreducible atomic conceptual matter we all possess (Katz 1975).

This must also be true of words that will not decompose in the first place, the Lockean simple ideas such as 'yellow', 'hot' and 'sweet', which he describes as having no other ideas contained within them and as ideas that can neither be created nor destroyed by us. These are in contradistinction to complex ideas that are compounded out of simple ideas, allowing compounds that do not exist in the world like 'centaur'.

'Yellow' can only be reduced to the atomic primitives 'colour' and 'yellow'. Some words, like 'move', can perhaps only be defined by truth conditions. If something is at A at t_1 and at B at t_2 then it moved.

Componential analysis has a close connexion with the lexical relations of hyponymy and incompatibility. Both lexical fields and also semantic features are useful in identifying hyponymous relations. Cruse (Cruse 1986) calls the atomic building blocks of meaning semantic traits. The meaning of a word: 'is viewed

as being made up, at least in part, of the meanings of other words'.

Such participants are known as semantic traits. Cruse stresses that no claim is made that they are primitive, functionally discrete, universal, drawn from a finite inventory or capable of giving an exhaustive definition of the meaning of any word. Cruse realises that his theory is descriptive and that

we have no grounds for believing that the meaning of a word, when viewed in this fashion, is finitely describable - without circumscription it is an unpromising candidate for formalisation.

Traits can be criterial, expected, possible, canonical, non-canonical, unexpected or excluded. For example,

- 'animal' is a criterial trait of 'dog';
- 'fish' is an excluded trait of 'dog';
- 'can bark' is an expected trait of 'dog' (the 'but' test: 'it's a dog but it can't bark);
- 'can sing' is an unexpected trait of 'dog' ('it's a dog but it can sing');
- 'brown' is a possible trait of 'dog' (it's a dog and it's brown);
- 'has four legs' is a canonical trait of 'dog';
- 'can fly' is a non-canonical trait of 'bird'.

Criterial traits have their origin in Aristotle, who attempted, not very successfully, to distinguish between essential and accidental attributes of things. This is easier for natural kind terms than for other words. Is a book always hardbacked?

Cruse's traits are akin to Coleman and Kays's (Coleman and Kay 1981) distinction between prototypical and typical features.

Compare also Rosch's (Rosch 1978) idea of a prototype or those

members of a taxonomic category that are more central than others. (See also Pulman 1983.)

We can generalise and simplify by saying that criterial traits suggest hyponymy, excluded ones suggest contradiction, expected traits suggest prototypicality and unexpected traits atypicality.

Componential analysis is attended with problems as we might expect. Language is never purely synchronic; besides idioms there are a lot of constructions one might call repeated discourse or fixed phrases, quotations and so on, that are not susceptible to commutation; there are also topographical, intentional and cultural differences in the meaning of words.

A very common example of a 'fixed phrase' is the metaphor 'the foot of the mountain' which blazed briefly for the person who created it but for most of us it is dead.

One could restrict structural semantics to functional lexical oppositions. We must bear in mind however that the norm abounds with idioms, quasi-quotations, buzz-words, expletives ('yet', 'already', 'still') and so on.

The arbitrary choice of primitive semantic features is also a serious criticism of componential analysis. It is sometimes held (pace Cruse) that a semantic component is part of a universal language-neutral stock of features from which each language chooses its subset. This is yet to be proved.

Katz (Katz and Postal 1964) believes that the semantics of English can be exhaustively represented by a lexicon and meaning composition rules or 'projection rules'. Bar-Hillel (Bar-Hillel 1970), however, objects that Katz's semantic markers or conceptual elements (supposedly derived from the senses) of the word 'bachelor' are ludicrous, including as they do, not only 'physical object', 'living', 'human' and 'male' but also 'serving under the standard of another', 'without a mate at breeding time' and the parochial 'having the academic degree for the completion of the first four years at college'!

Sampson (Sampson 1980) objects too that Katz and Bierwisch believe these markers to be derived from the senses or part of the human capacity respectively. But where does the feature 'male' come from?

Alternative componential analyses are also a problem: is an uncle a father's brother or a mother's sister's husband, and so on? Perhaps, given the paucity of real synonyms or synonymous paraphrases, it is neither. This is not a trivial point.

Chomsky admitted (Chomsky 1972) that semantic representations of this kind are not real identities because 'kill' does not mean the same as 'cause to die', 'raise' as 'cause to rise' or 'burn' as 'cause to burn'.

Curiously, the most ardent exponents of componential analysis see such problems as somehow inherent in language rather than their chosen methodology. Nida (Nida 1975) enumerates the 'difficulties' (but compare Austin (Austin 1940), who is

sceptical of the whole endeavour):

- lack of a metalanguage to describe the diversities of language (for instance, 'stink', 'stench', 'smell');
- difficulty of finding meanings that constitute a contiguous set; how is the spectrum to be represented;
- representing terms that differ, not componentially but in degree or intensity (for instance, 'toss', 'hurl');
- representing lexical relations (for instance, 'behind', 'in front of');
- representing relational features (for instance, 'colleague', 'friend').
- representing syntagmatic influences (for instance, 'good pianist', 'good dinner'; 'cricket ball', 'cricket averages'); some non-intersective adjectives are used paronymously, their senses here are not similar;
- the same words apply to a family of objects; if A resembles B and B resembles C but A does not resemble C, we may still call them by the same name (for instance, 'pleasure') but this name may not be susceptible to componential representation;
- one word (for instance, 'fascist') has many properties; on one occasion it may be used to denote one sub-set of these properties and on another occasion another subset; how can this be represented componentially;
- how do you know whether X is a component of Y or Y of X?; is 'extended' part of the meaning of 'shaped' or 'shaped' part of the meaning of 'extended' (Berkeley 1710)?

Even modest claims concerning semantic traits are attended by problems. It is not enough to say that if an attribute is used to infer category membership then it is criterial (Brown 1958). For zoologists, prawns and moths are both arthropods: an odd way of chopping up the world to some empiricists who would be more likely to use habitat as a criterion. The cerebral index is not a common way of distinguishing men and chimps. One man's criterion may be another man's noisy epiphenomenon depending on the way he divides up the world.

A case in point is the conceptual puzzle from Leviticus which divides animals into the categories 'clean' and 'unclean' for

dietary purposes. Camels, ostriches, crocodiles, mice, sharks and eels are unclean; gazelles, frogs, fish, most grasshoppers and some locusts are clean.

The philosopher Quine (Quine 1977) argues for a psychological and societal progression from an innate, similarity-based conception of kinds to a theoretically-oriented, more objective basis. Chemical, physical and genetic analytical techniques of classification have replaced perceptual ones. Ontogeny recapitulates phylogeny: children's conceptual techniques undergo this metamorphosis as they grow up.

It does seem to be true that concepts are intimately bound up with theories, Kuhn and Feyerabend arguing that scientists with different theories must have different concepts though possibly sharing the same nomenclature (for example, 'light' can refer to a concept in wave theory or in particle theory). Schank (Schank and Colby 1973) supports this.

A concept corresponds vaguely to what we might call a single meaning of a word, but the connection is more complex. Underlying the organisation is a belief that meanings cannot be reduced to any set of pure 'elements' or components from which everything else is built. Rather, a person categorises his experience along lines which are relevant to the thought processes he will use, and his categorisation is generally neither consistent nor parsimonious, nor complete. A person may categorise a set of objects in his experience into, for example 'chair', 'stool', 'bench' etc. If pushed, he cannot give an exact definition for any of these, and in naming some objects he will not be certain how to make the choice between them. This is even clearer if we consider words like 'truth', 'virtue' and 'democracy'. The meaning of any concept depends on its interconnection with all of the other concepts in the model.

Thus, it seems very difficult to say categorically what traits are essential to the definition of a concept (except for truisms: a dog has trait +canine). The only thing one can say for sure is that if two objects share a property then that property on its own cannot be criterial in assigning them to different categories. Of course, even to claim that category membership is determined by similarity to a set of properties is to make a curiously vacuous and circular claim. As Quine pointed out (Quine 1977), perhaps things only appear to be similar because they are members of the same category.

Of course, there are advantages in componential analysis. We can see that there are various lexical relations (hyponymy, taxonymy and so on) that are closely connected and might all be representable by componential analysis, as are other relations such as meronymy. This, however, makes the characterisation of semantic primitives even more rebarbative. It may be that they should be highly domain specific if they are to be of any validity at all.

Since it is not clear what the principled relationship is between a semantic feature and the word of which it is a component, there seems to be no reason why any lexical relation, for instance, meronymy, should not be implicitly represented by semantic features. Indeed, it would be very difficult to define, for example, a 'wrist', except in terms of other things to which it stood in a meronymous relation, such as the arm.

Are there any other lexical relations that could be represented by semantic features? Cruse defines the following. Rank terms are ungradable lexical units that operate on a discontinuous scale, for example, the military hierarchy, first-second-third, twins-triplets-quads, triangle-square-pentagon. Grade-terms are lexical units that operate over a continuous scale and are gradable, for instance, freezing-cold-cool-warm-hot-scorching, tiny-small-big-huge. Degree-terms are lexical units that operate over a continuous scale but are non-gradable for example fail-pass-credit-distinction, child-adolescent-adult. Proportional series are indicated by the linguistic frame: 'A is to B as X is to Y', for instance, 'duck is to duckling' as 'swan is to cygnet'.

It seems that all these relations could be represented in a lattice structure in which the more semantically primitive elements were higher in the structure. Thus 'swan' and 'duckling' would both inherit 'animate' but only 'swan' would inherit 'adult'. The comprehensive nature of such a lattice, which could loosely be called a hyponymy lattice, is enjoyed at the cost of representing a great many lexical relations only implicitly. For instance, the sequential nature of 'first' and 'second' would be lost and only their common ancestry explicit (common ancestors being 'adjectival', 'ordinal' and so on).

It is also true that componential analysis is not an ideal

method of representing semantic relations such as symmetric, transitive and associative relations (for instance, X is parent of Y; X is taller than Y, and so on). Nor does it handle indexicals, performative utterances or paraphrases (A precedes B; B follows A). No meaning is represented apart from a contrastive lexical kind (denotative meaning: father = male; connotative meaning: father = caring), thus encyclopaedic knowledge, however relevant (a father is probably over twelve), is excluded. It is also the case that some words would require complex componential analysis in that they do not necessarily point to any concept but merely delimit an area negatively as being not like some other.

The idea of lexical decomposition has great descriptive mileage but is, unfortunately, formally intractable. Some features like 'plural', 'mass' and 'masculine' have been adopted in feature-based grammar formalisms being a bridge between syntax and semantics. Beyond these obvious features is a proliferation of possible features of differing granularity and intrinsicity. There is no principled way to circumscribe them. Fillmore believed the definition of semantic components must be arbitrary.

Thus, despite the specious attractiveness of componential analysis, at the end of the day we cannot abandon model-theory entirely in favour of such a system. Of course, model theory has its limitations too: linguistic differentiation does not correspond to reality, being sometimes more granular (colour

terms for the continuous spectrum) and sometimes less ('bric-a-brac' for numerous distinguishable items) (Cruse 1986).

Also, some words do not have observable denotata in themselves ('listless', 'irony'). It seems, however, possible that one could do a compositional job on such words reducing them to primitive elements and that those elements might turn out to be, not semantic features, but observable denotata. However, the conceptual bricks favoured by Katz (Katz 1972) are of different kinds, for instance, 'bachelor' and 'widower' would share positive features 'animate', 'male' and 'adult' but would have positive feature 'never married' and negative feature 'never married' respectively. Whatever the minimum primitive set is, it is, unfortunately, not the same as that set of concepts that has demonstrable denotata and thus cannot be accommodated easily into a model-theoretic semantics.

We may feel at this point that we have travelled an uncomfortable distance from the external world which, to be fair, came in very useful in providing meaning for a lot of serviceable words like 'cup' and 'green'. As Aitchison (Aitchison 1978) points out, some words which appear to be amenable to compositional analysis are tricky: is not a non-stripy or non-carniverous tiger still a tiger? A lot of people would think that this inherent immutability was true of all natural kind terms or rigid designators. Surely some primitive concepts are best explained referentially?

Of course, we are not forced onto the horns of this dilemma between structural and non-structural theories of meaning. Aitchison (Aitchison 1978) abandons the idea of a unary semantic principle:

meaning is double-faced. The meaning of a lexical item such as 'tree' must be considered in two ways: first of all as one element in a language system whose meaning is dependent on relationships with the other words in the system. Second its meaning is linked up with a certain class of recognisable objects in the external world.

To review for a moment, we can see that the present discussion of linguistics, from field theory to semantic traits, is a long way from where we began: namely what might be called the black box approach to words. To a philosophical logician, each word has a discrete external function and what is inside it is not his concern. Predicate calculus was not designed to express lexical relationships. The uncomfortable accretion of meaning postulates to Montague semantics shows us that logical form went a long way down the road of truth-conditional semantics and model theory before lexical relationships were incorporated.

This doesn't mean that lexical semantics is a fruitless endeavour but merely that it was not the concern of logicians like Russell and Frege to root out lexical dependencies but to formalise truth conditional semantics. To the lexicalist a word is more a box of delights than a black box.

Of course, to give a full account of language we need a

marriage of formal and lexical semantics. Is such a synthesis possible?

3.4 Thematic roles.

Transformational grammar made an attempt at synthesising formal and lexical semantics by incorporating thematic roles (theta roles; participant roles) into a fairly formal system. A number of linguists have addressed themselves to a study of thematic roles under various guises of nomenclature.

The characterisation of thematic roles, apparently a real attempt at uncovering general semantic principles concerning the functional semantics as opposed to the logical semantics of words, attempts to characterise the semantic function of syntactic structures.

In frame analysis (Fillmore 1975), a case framework for a verb is a specification of the syntax and/or semantics of the concepts that can be associated with that verb and the cases are, for example, agent, beneficiary, recipient and so on. The point of the structure is to provide slots into which later comprehension processes can look without having to contend with the complexities of the original sentence which may include passives, tenses, prepositional phrases and so on.

In functional grammar (Matthews 1981), 'predicate frames' are listed in the lexicon. These specify a number of arguments (for instance, agent, goal and so on) and from these frames

predictions can be made about the contents of the arguments.

Other grammars with similar aims are the lexical functional grammar of Bresnan and Kaplan and the functional unification grammar of Kay.

Relational grammar (Postal 1976) was developed in reaction to transformational grammar, elevating the notions of subject and object to positions of importance. This can be unproductive in some sentences where subject/object distinctions aren't obvious, for example:

Father Blaney weighs seventeen stone

The theta theory (theta for 'thematic') in Government and Binding Theory also attempts to account for the relationship between verbs and their arguments, the theta role, or thematic relation, being the argument. The theory determines under what circumstances an NP can be the argument of a verb, the different kinds being, for instance, agent, patient (or theme) or goal, and attempts to make syntactic generalisations to this end.

X Bar Theory is a variation of the phrase structure component of transformational grammar. To say that a phrase structure rule is $A \rightarrow B$ where B is any set of non-terminal or terminal symbols, is too powerful. Heads are linguistic universals and phrase structure rules should capture them. The theory also incorporates theta roles or the thematic or participant roles of Fillmore.

The function of thematic roles is to enable us to generalise about similar constructions that have different meanings.

Lachlan had a skean-dhu
Lachlan had a holiday with the Salvation Army

They also explain restrictions on co-ordination and sentence order and expose similarities in meaning where different constructions are used.

McBride burned the incense on Sunday
the incense burned on Sunday

Sir Bigshot Bagott opened the pilchards with his Osmiroid
the Osmiroid opened the pilchards

Typology of participant roles is debated. In the previous example McBride is deemed to be the agent. It is not agreed whether this would still be so if the subject had been 'fire' or 'the robot'. Other classes have been suggested such as 'force' or 'machine'. The finer the distinctions made between different semantic categories, the closer the study of thematic roles comes to lexical semantics rather than functional semantics. Amongst about thirty roles suggested for X in the phrase 'with X' have been:

the thurible is with the candlesticks	(location);
he weighted the sack with the candlesticks	(instrument);
he fell into the moat with the candlesticks	(comitative);
make the molten metal with the candlesticks	(ingredient).

Such an explosion of classes could be reduced by extirpating contingent and situational attributes from the analysis and concentrating on grammatical and lexical attributes. There

could also be a restriction of one participant role per clause although this creates problems distinguishing between complement (goal) and adjunct (goal).

he sent a bridie to the oubliette for Fons

Other roles are benefactive, recipient, patient, source and goal.

the priest slipped from the vestry (source)
the priest slipped into the barouche-landau (goal)

Some verbs must take certain participant roles, for example,

pour into/onto
place in/on
fill with
clothe with
cover with

The analysis of participant roles is vague and inconclusive. More importantly, participant roles are context dependent. There is no reason to suppose that 'into the barouche landau' has the thematic role 'goal' in some kind of intrinsic way. Compare

the field mouse slipped opportunistically into the barouche landau
the highwayman fell clumsily into the barouche landau

The vehicle is not a goal in any real sense in the latter example, and to deem it so is merely conventional and lacking in explanatory power. The most we can say is that the phrase is adverbial and spatial.

The following adverbials are difficult.

the vicar cleaned the pond with the boy scouts
the vicar crossed the moor with his compass
the vicar printed the parish magazine with a computer
when I ate the india rubber I cut it into eight pieces
when I ate the india rubber I forfeited my exeat

A solution to the first three examples is to say that there is only one 'with' role (comitative) but that each object changes the meaning subtly. The latter two examples demonstrate that an adverbial introduced by 'when' can have temporal or teleological force.

To many people, syntax is grammar and semantics is grammatical functions. This is very crude but it is nevertheless true that grammatical functions provide a useful starting point for a study of semantics. The definition of even grammatical functions is, however, rather woolly. For example, indirect objects are often only defined by means of a list of verbs deemed to take them. Certain transformation rules do not work for all indirect objects either, making the class difficult to define.

he gave the thurible to O'Connell
he gave O'Connell the thurible

Sparrow attributed the work to Housman
*Sparrow attributed Housman the work

It cannot be said that complements are always indirect objects for sometimes they are directional adverbs:

he gave the burse to Father Shaugnessy

but

he put the holy water into the piscina

Defining the notion of subject is also difficult and it cannot be recognised in some languages. One can only establish a list of subject-like characteristics (Matthews 1981). The subject cannot usually be eliminated. Subjects normally express the agent of an action and the addressee of imperatives.

Given all these problems, it is not clear whether, even if a set of thematic roles could be characterised at a necessarily fine level of syntactic granularity, that it would be of any significance.

3.5 Computation and unification formalisms.

Before leaving this survey of interdisciplinary semantics a few words should be said about a mechanism used widely in computing which realises some of the theoretic notions outlined above.

Computational power has been harnessed in the service of several areas of linguistic research including the construction of concordances, word-frequency analyses, speech-analysis, parsing and language-generation and also semantics.

While it would be superfluous to enumerate all the computer systems in computational linguistics and artificial

intelligence according to their semantic components, one mechanism stands out as significant in the context of componential analysis.

Unification has its origins in mathematics but has especial value in any application where a large amount of potentially disparate information has to be synthesised. This is obviously the case in natural language parsing and it has seemed a good idea to some to include semantic, pragmatic and indeed any other constraints when sorting out the possible interpretation of a string of words. Thus semantic pruning does not come in at the end of the computational process but concurrently with syntactical analysis. (The pros and cons of these alternative methods must be weighed carefully: it is not obviously more efficient to do the job either way.)

Another advantage of unification is that the mechanism provides an economical way of representing the common heritage of many lexical items. For instance, the lexical information pertaining to a transitive verb can be represented once and thereafter inherited by all transitive verbs.

Karttunen (Karttunen 1986) claims that many grammars such as LFG, HPSG, CG, CCG, relational grammar and some versions of GB can be represented by the graph-unification formalism D-Patr from Xerox Parc and it is easy to see how. Other grammars written in Prolog, which is a term-unification language, exploit unification as do grammars like UCG written on D-Patr. Advantages are order-independence of rules and the handling of

partial information. Semantic constraints are handled by means of features for polarity (+ve/-ve), tense, tense aspect (simple/perfect), mood (indicative/conditional/potential), type (declarative/imperative/interrogative). For example 'loved' would have features positive, past, simple, indicative, declarative. Another advantage of the unification formalism is that it is surface-based.

It must be said that insofar as the above grammars and others not detailed (for example, LFG, FUG, GPSG, HPSG and DCGs) are concerned, the semantic component is either very rudimentary and restricted to what might be called logical semantics and the entailments of function words, or else offers a simple type hierarchy of concepts and the semantic features attached to them, thus, for example, 'flow', 'drip' and 'trickle' might all be assigned to the same class and impose a restriction on any subject noun that combines with them, namely that it be some kind of liquid (contrast, 'the information flowed').

Unification formalisms like PATR offer scope for over-riding although this introduces non-monotonicity and sacrifices the potential for order independence of rules. The system also allows lexical redundancy rules to express relations like active and passive although this is outside the methodology of PATR, transformations again jeopardising order independence.

LFG allows aggregation of incompatible information using some suitable criterion for deciding what over-writes what.

As Shieber (Shieber 1986) says, the structures offered by a grammar formalism should be appropriate for expressing linguistic information. It is a fair question to ask whether the structures offered by unification grammar formalisms are appropriate. There are various caveats: templates are not a class of objects defined by linguistic criteria; subsumption lattices are not organised according to linguistic strata but computationally motivated; D-PATR rules are complicated; unification is not a procedural process; inheritance (without over-riding mechanisms) is possibly not a property that is sufficiently general in linguistic structures for one to build a grammar around the notion. Having said that, the computational elegance of unification is so seductive that it has been exploited in all sorts of artificial intelligence contexts. Computational elegance however should not be used to justify incongruous applications.

Some linguistic phenomena seem however to be particularly suited to unification treatment. Homonymy is multiple ambiguity of phonologically similar words (for example, the two meanings of 'bible' (a holy book; a cow's stomach)). This is a problem which can sometimes be solved in computation by unification of feature sets or in linguistics by the imposition of selectional restrictions. For instance

Vernon was reading a bible

may carry selectional restrictions on the verb 'to read' such as 'takes an inanimate object'. If only one of the two lexical

entries for 'bible' has the feature 'inanimate' the problem on this occasion is solved. It is not as straightforward as this of course. Even excluding metaphor and poetic style, Vernon could be reading the entrails of a cow as one reads tea-leaves!

Polysemy refers to the related but differing senses that one word may have or the vacillation of meaning or sense of a word from context to context, for example, 'man' in 'man has a vectorial spirit' and 'a man sat on a drawing pin'. This class of words facilitates puns. An example is 'met':

I met my wife in Paris which was embarrassing as I had told her I was going on a business trip to Widnes.

This is a problem: should one have separate lexical entries for such a word or is there a minimal feature set that is common to all uses of the word and a number of variable features on each that take the colour of the local context? A natural inclination for parsimony makes us move to the second solution.

Another way to classify these kinds of lexical items is as ambiguous and vague. One could say that 'bible' is ambiguous and that 'man' and 'good' are vague. The common solution to both is a kind of negotiation procedure where each word contributes its heap of semantic elements and the vague words contribute also indeterminate features with a range of possible values. The syntactic rules that build constructions would also unify feature sets discarding incompatible values.

Unification seems to be a powerful mechanism both for parsing and also for lexical semantics that enables one to test the operational feasibility of notions such as componential analysis that were hitherto merely theoretical.

Chapter 4. A semantics of prediction and coercion: background.

The following four chapters deal with the special semantic problems of, on the one hand, predicting the meaning of unknown words from their neighbours, and, on the other, resolving semantic anomalies. These two aims are not unrelated since coming across an unknown word in a text is rather like discovering an anomaly. At any rate we are brought up sharply by a piece of text that cannot be understood literally or cannot be understood at all.

Chapter 4 discusses the background to the semantics, the grammar and the classification of words into basic ontological types.

Chapter 5 deals with the need for a semantics of prediction and coercion and discusses alternative approaches to the problem.

Chapter 6 deals with the principle for predicting the meaning of unknown words.

Chapter 7 handles semantic coercion and the principle of anomaly resolution.

4.1 Fashion.

From previous chapters, despite a lengthy assessment of current lexical semantics, we can see that the study of word meaning (what is inside the black box) along with philology and

etymology, first pursued by the Stoics, has been, to some degree, marginalised since it has not proved amenable to the twentieth century post-Fregean paradigm of the scientific or formal treatment of language. Aesthetics has enjoyed the same isolation in philosophical circles since it does not reward formal analysis in the way that other philosophical topics do. Ethics yields to a utilitarian treatment for instance.

Thrax's Greek grammar from the first century BC identifies (though he did not get round to them all) six different elements of grammar including explanation of principal poetic tropes and mythological examples, etymological derivations, identification of proportional series and poetic criticism. Boils can mean a particular configuration of spots or they can mean bubonic plague or they can mean imminent demise. Scientific description may be more precise than any other explanation but not necessarily of greater epistemological significance.

It is a mistake to demean all aspects of the world and language in particular that will not yield to reductionist treatment. As Wittgenstein, swimming against the tide, in the Philosophical Investigations, put it (Wittgenstein 1953):

we are not striving after an ideal as if our ordinary vague sentences had not yet got a quite unexceptionable sense and a perfect language awaited construction by us...

Thus, anomalously, even as the linguists were breaking away from the treadmill of descriptive linguistics and beginning to

formalise generative grammar, the philosopher Wittgenstein was forswearing all formal methods and advocating descriptive semantics alone (ibid.):

we may not advance any kind of theory. There must not be anything hypothetical in our considerations. We must do away with all explanations and description alone must take its place.

Thrax's description of grammar is translated as technical knowledge, one of the four Aristotelian divisions of knowledge, namely, one that uncovers underlying principles but, notably, not 'episteme' or that branch of knowledge that reveals all the causes of something, revealing it as being necessarily the way it is. This suggests that we should recognise grammars as provisional, not a distillation of language but a normative description of it. In Varro's *De Lingua Latina*, written in the first century BC, he concludes that, contrary to the polarised views of the day, language is the product of both regular laws and also non-deterministic human choice.

It is important to realise that twentieth century formalism is largely a matter of intellectual fashion and not necessarily an inherently superior methodological approach. The question of whether the universe and language are subject to laws (the analogy / anomaly controversy) taxed the ancient Greeks. Formal methods are fraught with problems. It is often mistakenly believed that a particular formalism is a distillation of everything that there is in the field in

question when it would be more reasonable of its creator and disciples to admit, as Montague did, that only a fragment of the field is accounted for. This problem also arises in artificial intelligence where there is often a qualitative, and not merely quantitative, difference between some micro-world under investigation and reality.

Another example of the inadequacy of formal methods when dealing with organic subject matter is Roger Williams' extrapolated tenth symphony of Beethoven. The critics suggested that Beethoven's egregiousness lay in part in being able to write music he hadn't written before rather than music he had. Sampson, after Popper, believes one can not have a science of thought, since thought involves ex-nihilo hypothesis plus sensory evidence while science involves prediction. Semantics is creative, because it is built on the speaker's beliefs which are creative, therefore it is not scientifically describable and no general theory of language is possible. We should, as Wittgenstein recommends, go back to descriptive linguistics and lexicography (Sampson 1980).

Of course, formal semantics may not be attended with problems in the future, but we should remind ourselves that there is no reason, except scientific fervour, why we should necessarily assume this.

4.2 Aims of the theory.

It seems to me that neither the formalist nor the descriptive linguist is entirely right. Those who fear that formal semantics is some kind of vivisection of what is an organic human creation, or, alternatively, blasphemy against something sacred should be aware that there are still insuperable hurdles to be overcome concerning the representation of meaning.

For one thing, only a handful of words function purely as logical operators. The rest of language is laden with contextual nuances, contingent factual information and distant metaphorical senses. Our understanding of nouns draws on a vast network of world knowledge ('hotel', 'breakfast'); no adjectives or adverbs are entirely intersective but are to some degree context-dependent ('red hair', 'red roses'); verbs are extremely susceptible to metaphorical shift ('break the moustache-cup'; 'break the tradition'). Some kind of exhaustive syntax-based context-free set-theoretic account of semantics seems out of the question.

This, however, seems very dissatisfying. Surely we can strip words of their connotative and context-dependent meaning and give a principled account of the semantics of what is left. After all, a great many words merely refer to everyday objects, events and properties out there in the world. It is hard to believe that they combine together in sentences in an entirely unprincipled and whimsical way.

This seems to me to be a clue to a principled approach to semantics. Establishing reference for the words we use is, first and foremost, an ontological question. What sort of a thing is a foot-warmer? How does it differ from the sort of thing a faux-pas or a fortnight is? What are the basic ontological types? How do they inter-relate? To what extent are they fixed or do they exercise selective and coercive powers over each other?

Before a detailed discussion of these questions I will describe the basic building blocks of the semantics to be used, namely, the hierarchy of semantic categories, the classification procedure that assigns words to these categories, the lexicon of basic English words that is incorporated into the semantics, the grammar and the fragment of language with which the semantics deals.

The research has three overall aims, namely, to use the semantics

- a) to predict the semantic class of an unknown word from a known word in text adjacent to it;
- b) to predict the semantic class of a linguistic structure from its components;
- c) to make domain-independent inferences from well-known English words for the purposes of elucidating and propagating texts.

4.3 Semantic hierarchy.

It is assumed that there is a semantic hierarchy of basic ontological types and that all words can be classified into one of four ontological classes (for instance, 'dog' belongs to the class animate) according to the ontological types of their referents.

Something should be said about hierarchies.

Cruse (Cruse 1986) says that hierarchies can be branching or non-branching. They must be directional, that is asymmetric. They must be catenary, that is, they can, in principle, form a chain of elements not just two (this excludes relations like 'is husband of'). They may be transitive or intransitive. They must have only one root. The branches must not converge (this excludes lattices and relations like 'is larger than'). Examples of hierarchies are taxonomies and parts explosions.

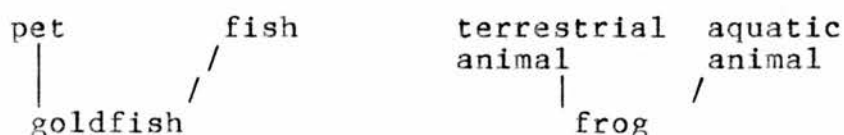
To some extent it seems stipulative to say that a lattice structure cannot represent a hierarchy. Chambers Twentieth Century Dictionary gives the following definitions of hierarchy (Chambers 1983):

classification in graded subdivisions;
a body or organisation classified in successively subordinate grades.

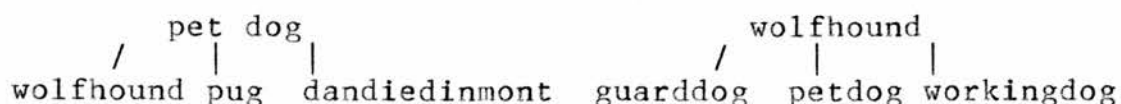
Neither of these definitions is incompatible with a lattice structure (remember a lattice may have only one root).

One may feel intuitively that it is part of the definition of a hierarchy that, for any two members of that hierarchy, it is possible to say which is the more senior. This test however is equally inapplicable to trees and lattices. Cruse's stipulation that a lattice cannot be a hierarchy may come from the paradigm of human organisations. Office-boys, corporals, programmers and farm-hands usually report to only one boss; it is confusing if they don't. This may suggest that hierarchies cannot be lattice structures but are tree structures or linear.

Hyponymous relations can be represented by a hierarchy. Not all hyponymous terms however can be represented by a tree structure, unless we restrict ourselves to natural kind terms. Consider the following. The lines can be read (from bottom to top) as 'is a kind of'.



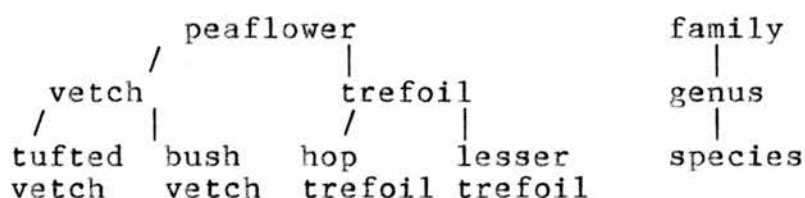
It seems to be a mistake also to think that there is necessarily a hierarchical structure independently of the relation used. To show this we can construct hierarchies where hyponyms and superordinates swap places:



This is not supposed to represent natural kind terms and so

there is no preferable orientation of these hierarchies. It all depends on one's point of view. In a book or a semantic feature database about pets, 'wolf hound' would, by default, contain the semantic primitive 'pet'. In a book or database concerning wolf hounds, pet dogs would, by default, contain the primitive 'wolf hound'. Data is only recognised as data in a specific domain. For instance, paper money is flammable but such a property would be irrelevant in nearly every context (Medin and Shoben 1988).

Non-branching hierarchies can be derived from branching ones or just be linear relations of dominance. If you label the levels of a branching hierarchy (with abstract entity labels not classes) you get a non-branching one. Here is one of Cruse's examples of a transitive branching hierarchy and its non-transitive non-branching abstraction:



Another way to reduce a branching hierarchy to a non-branching one is to provide a single superordinate for all items at each level. You can't do this with a taxonomy however because taxonomies are transitive and any superordinate for a level would also be an appropriate superordinate for all levels below it.

Cruse claims that sometimes a branching hierarchy exists but

there are no words for it, for instance, unit-of-measure hierarchies and military hierarchies. These can be represented linguistically as non-branching hierarchies with labels like 'centimetre' and 'colonel'. It is difficult to see how one could represent these as branching hierarchies though. A ruler may comprise twelve inches, each of which comprises ten tenths of an inch but it is difficult to represent this as a hierarchy. For one thing, every tenth (unless uniquely named) stands in the same mathematical relation to every inch, which would generate some kind of lattice structure that Cruse, as we have seen, claims cannot be a hierarchy.

Other non-branching hierarchies are what Cruse dubs linear relations of dominance. They are asymmetric and catenary with relations like 'is bigger than'. In some hierarchies the relation is a salient property or criterial trait of the elements, for instance

mound-hillock-hill-mountain.

In others it is just an expected trait, as in

dog-horse-elephant.

Cruse distinguishes hierarchies from chains, the latter having no inherent traits that provide the relations but forming a chain because of spatial or temporal ordering, for example

shoulder-arm-hand,
birth-adolescence-adulthood-death.

Cyclical chains are called helices. Examples are

Monday-Tuesday-Wednesday

the spectrum, the seasons and times of day.

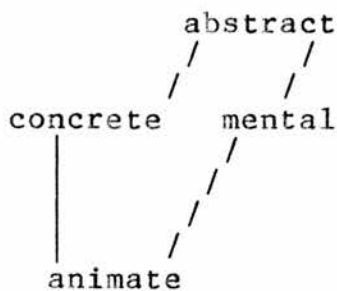
The hierarchy adopted by this thesis comprises four fundamental classes standing in a linear relation of dominance, from lowest to highest, viz

concrete animate mental abstract

A definition of each of these classes is given in Section 4.4.

This relation of dominance will become crucial later on in the characterisation of the principles of prediction and coercion.

The relation of dominance between these classes should be distinguished from their ontological relation however, which is slightly different.



It will be observed that such a structure is not, in Crusean terms, a hierarchy since it is, in fact, a sort of lattice. However, just as a frog is both terrestrial and aquatic, (most) animate objects are both concrete and mental. We cannot

pretend that this paradoxical state of affairs does not exist, or that if it does, it is not inherently hierarchical.

Wherein lies the hierarchy?

To follow in Cruse's footsteps we need a useful schema. I suggest

nothing can be X if it isn't Y

where Y is the superordinate and X the subordinate in a hierarchical relation. Thus, nothing can be animate (for example, a man) if it is not both concrete and mental and nothing is mental (for instance, a thought) that is not abstract. Likewise, nothing is concrete that is not abstract in the sense that it has some abstract dimension of functionality (for example, sand is unsuitable for building on, a protractor is a device for drawing angles, and so on). On the other hand there are abstract objects that are not mental (for example, a possibility) and concrete ones (for instance, a scythe) that are not animate so there is no other appropriate configuration for the lattice: it could not whimsically have been the other way up, for instance.

The ascendancy of abstract over concrete in these hierarchies is neither arbitrary nor insignificant. Abstract terms denote all that is most significant to the intellectual life and finer sensibilities of civilised man. Locke believed that what distinguished man from beast and civilised man from primitive man were his powers of abstraction. This is taken up by

Bloomfield (Brown 1958).

The surface study of semantic change indicates that refined and abstract meanings largely grow out of more concrete meanings.

There is also evidence (see below) that ostensive meanings have chronological precedence over abstract meanings in language acquisition (although this in itself is not a sufficient reason for abstract readings to be preferred to concrete ones in a case of ambiguity).

The first of the above hierarchies is a coarse-grained representation for simplicity. The large grain size means that, when we discuss anomalous linguistic structures, some anomalies are not identified (for example, 'the dog winked') as the components of such anomalies fall under the same class.

One further semantic class, the class figurative has not been mentioned before. The class is unusual in that it applies only to combinations of words and not to individual ones.

Figurative usage occurs when abstract adjectives, adverbs and verbs concerning the psyche (that is, the cognitive, emotional and intentional life of man) occur in conjunction with concrete (that is, appertaining to inanimate matter) nouns, verbs and subject nouns respectively. This marriage usually begets androids or android-like events, for example

the peevish bicycle
output the document eagerly
the scythe repented

We may think that this is merely a case of coercion that can be incorporated into our general theory somehow, but examination of the first example shows that there is no coercion. The bicycle is still, in essence, a bicycle and the peevishness still, in essence, a state of mind. Comparison with the phrase 'a hot temper' demonstrates the difference. A hot temper is still, in essence, a temper but is not in any literal sense hot. We may argue that a hot temper does not literally exist and therefore the phrase should perhaps be classified as figurative but this is to reject the conventional interpretation of the phrase which is that it refers to a kind of temper that does really exist but is not really hot. The phrase has yielded to coercion in a way that figurative phrases do not: they resist ontological classification into one of the four primary classes.

Single words do not seem to be inherently figurative, since, despite problems of existence, they are always ontologically classifiable into one of the four fundamental classes, for example

ambrosia
sky-blue-pink
magical
Bulldog Drummond
phlogiston
boggart
fictitious

All these words refer to objects or properties about which there is some uncertainty, for instance, one is unclear about

the colour of sky-blue-pink but assumes it would refer to a concrete quality. Likewise one is sceptical about the existence of Bulldog Drummond but one assumes the name would refer to an animate object. 'Fictitious', while it is a property of non-existent objects is not a non-existent property but has the ontological class abstract. We have a good concrete definition of phlogiston (an element separated from every combustible body in burning): there just happens, along with Biggles, moly, worricows and other denizens of possible worlds, not to be any around the place.

The fact that the above list of words refers to things that do not exist in the real world need not make any difference to our semantics. After all, we can talk about, say, a pink hat, quite intelligibly, with a respectful avoidance of anomaly and contradiction, without caring about whether it exists or not.

This is true. However, if we had no idea to which ontological class hats in general belonged then we would not need to guard against anomalous or contradictory discourse about them since there could be no such discourse. One does not economise in daydreams: they cannot be too baroque or vainglorious. Likewise, discourse about non-existent ontological types like peevish bicycles cannot be anomalous. In these circumstances we can say what we like and a semantics of prediction and coercion is redundant.

The semantic class figurative is included here for completeness since some combinations of words are figurative. However, it

is excluded from the semantic hierarchy since it has application only to linguistic phrases and not to individual words.

4.4 Classification of known words.

Known words must obviously be classified if we are to use them for predicting the classes of unknown words.

The following criteria are used to determine which of the five semantic classes should be assigned to a word.

Animate. The class animate is assigned to words that denote any object, action, state, event, process or property that is apprehensible by the senses and can only be, be executed by, be enjoyed by or be inherent in, an animal. For example, the following words are classed as animate: boy, to hide, to be lame, to be sick, to write, flatulent.

Concrete. Any object, action, state, event, process or property that is apprehensible by the senses and can exist, be executed or obtain in the absence of an animate object (for example: dust, to fall, to decay, a volcano, erosion, black).

Mental. Any object, action, state, event, process or property that is not apprehensible by the senses and is, is executed by, is enjoyed by or is inherent in, the human mind (for example, a dream, to decide, anxiety, a thought, ratiocination, contrite).

Abstract. Any object, action, state, event, process or

property that is not apprehensible by the senses and does not come under the previous classification, and is not figurative (see below) (for example: a lemma, to vitiate, impossibility, yesterday, to elapse, old).

Figurative. Any object, action, state, event, process or property that is the result of combining an abstract adjective, adverb or verb concerning the psyche with a concrete noun, verb or subject noun respectively (for example, a cheery tank-engine, fell apart with relief, the fountain mourned, a churlish thunderstorm, the oaktree pondered).

If a word genuinely falls between two classes (for example, 'man', 'brainchild', 'song') or if a word has more than one use (for example, 'break' in 'break the plate'; 'break the tradition') then the word is classified in the lower class of the two. One can think of this as a default class. If a word has two meanings (homonymy) then it has two entries in the lexicon and two classifications.

I accept the traditional distinction that concrete nouns are those that represent things or properties that could be apprehended by the senses if they existed. This includes 'redness', 'bucket', 'rustlings', 'cold', 'bitterness', 'smells', 'ambrosia', 'unicorn' and 'Sherlock Holmes'.

The traditional distinction between concrete and abstract when applied to attributes can be re-worded as a distinction between formal and functional attributes, for example, the attributes

of colour, shape, weight and so on are formal, while those of purpose, for instance, 'having the function of slicing bacon' and 'being a chiropodist by profession' are functional.

(There is possibly potential also in distinguishing between Cartesian primary and secondary qualities, that is, on the one hand, qualities to be found in all bodies like solidity , extension, figure and mobility, and, on the other hand, powers in the object to produce ideas in us that do not resemble their cause, for instance colour, taste and smell.)

The classes mental and animate, although, according to the above ontological hierarchy, they derive from the basic classes of abstract and concrete, are, nevertheless, primary classes in an anthropocentric world. By 'primary' I mean that there are single words that should be classified as animate or mental, for example 'horse' and 'reproachful'. 'Mental' includes the cognitive, emotional and psychological faculties of man. Anthropocentricity is not usually a consideration in lexical semantics, the motivation usually being to organise words according to the hierarchy of natural kind terms or lexical fields or some other schema. This is curious when one thinks about it since language is a human creation with human concerns in mind. If language is preoccupied with the mental and physical life of man we should not be surprised.

Here is a sample lexicon of the primary semantic classes, built according to the above classification method.

	concrete	animate	mental	abstract
adv	loudly	loquaciously	angrily	controversially
adj	metal	forlorn	contrite	French
noun	bucket	man	mind	theory
verb	output	avoid	despise	vitiate

As we have seen, the two basic classes are concrete and abstract, concrete being all those things that are apprehensible by the senses and abstract being everything else. Thus, the elements in the column headed 'concrete' are all apprehensible by the senses. (This is pace Putnam's reservations about the common man's ability to identify a concrete substance like, say, gold. We are talking here about what is apprehensible not what is identifiable.)

We can see and touch metal buckets, hear a bell ringing loudly and see a printing machine outputting paper. On the other hand, abstract things are not apprehensible in this way. We cannot touch or smell a theory, (literally) see that something is French or glimpse an argument being vitiated. Nor can we see that someone is executing their duty controversially.

The two remaining classes are secondary classes, thrust into prominence by the anthropocentric nature of language and the world of discourse, namely 'animate' and 'mental'. The class animate is the progeny of the ontological classes concrete and abstract in the ontological hierarchy. Animate subsumes so many words that it deserves to be identified as a class in its own right. 'Mental' deserves to be identified as a class in its own right for a different reason, namely that, although

mental objects are abstract, nevertheless they have the unique distinction of being, in some sense, situated in (or epiphenomena of) animate objects.

Thus 'man' is an animate noun. 'Forlorn' is also animate because it cannot properly be said to subsist in the absence of any animal. 'Avoid' is animate because it requires an animal to realise it, and 'loquaciously' is animate because it is a property that cannot subsist in the absence of an animate action, state, event or process.

The noun 'mind' is a mental noun. 'Contrite' is classified as a mental property because it cannot exist in the absence of a mind. 'Despise' is a mental verb because it presupposes a cognitive agent. Likewise, 'angrily' presupposes a mental state, action, process or event.

One or two of these examples may seem whimsical. For instance, a French man is surely apprehensible by the senses. Why then should the adjective French be deemed abstract? Or, if it is, then surely so is the property of being a man and indeed any property.

This is not so. For one thing, it is perfectly possible for something to be French and yet this Frenchness to be quite undetectable by the senses. However, it is difficult to imagine that something could be a man and yet his 'manness' be undetectable by any sense whatsoever (given, of course, an observer and reasonable conditions).

But, it may be argued, suppose the man is wearing a bustle, rouge, Rive Gauche and singing Voi Che Sapete? Detection might be impossible. This is even truer of, say, a traffic-warden in his pyjamas. The senses would not apprehend his day-job.

The answer is that, granted, a traffic warden, or even a man, might escape detection by the senses but not qua animate object. Thus they would both be classified as animate for the purposes of our system.

It is tempting to think that all properties are functional ('old', 'French', the property of being a secretary and so on) and thus not apprehensible by the senses, but this does not seem to be correct. Granted you can see a French waiter but not see his Frenchness. However, you can see a pink geranium and also see its pinkness. Of course, you cannot smell its pinkness but this is not required. Detection by one of the senses is enough.

Another troublesome example is the concrete verb 'output'. Why, it might be asked, should we use such an awkward neologism when plenty of other words will do? The answer is that the only transitive verbs that are exclusively used with concrete subject nouns are neologisms such as 'autoprint', 'output' and so on. Verbs like 'hit' and 'cut', although classified as concrete, often have an animate agent behind them and thus are not ideal prototypical examples. Of course, there are intransitive verbs that can take concrete subject nouns, but few of them exclusively so. Buckets can, indeed, fall, rattle

and shake but then so can animate objects. 'Fall apart' is perhaps a better example of something only concrete objects can literally do without losing caste!

It is a mistake to think for a moment that every word fits neatly into one of these four discrete groups. The reality is a continuum and this in itself can affect the semantic result of combining two words. The continuum is built up by beginning with the lowest class, concrete, in its most brutish instantiation (for instance, sand, iron) and, by minute accretions of animacy, mentality and abstraction to move up to the highest class, abstract, in its most rarefied instantiations (for instance, impossibility, proof).

The nature of the hierarchy as a continuum or, in actual fact, a circle, can be demonstrated by the following nicely graduated sequences of words:

bucket-aphid-dog-man-trumpetmajor-mind-ideology-brainchild-theory-novel-book-bucket

metal-black-forlorn-contrite-devious-traditional-technological-metal

output-manufacture-strike-cower-despise-refute-vitiate-undermine-output

The classification of words into the four primary classes (and one secondary class) can be extended to cover complex phrases that can nevertheless be reduced to simple parts of speech. Thus, in 'the prisoner in the oubliette', 'in the oubliette' would be classified as a concrete adjectival phrase (or noun modifier) which can loosely be called a concrete adjective.

Likewise in 'tortured with the bastinado', 'with the bastinado' would be classified as a concrete adverbial phrase, or verb modifier, which can loosely be called a concrete adverb.

Of course, this initial four-way classification is rudimentary. There are much finer-grained classifications available, for example concrete-mass, concrete-liquid and so on. Violation of expected classes of this sort causes prototypicality mistakes, such as

Beasley drank the school assembly hall.

The idea of classes of meaning is derived from Aristotle (Ackrill 1987). In the *Categories* he suggests the following classes (examples follow in parentheses):

substance (horse);
quantity (three yards);
quality (white);
relation (half);
place (in the Lyceum);
time (yesterday);
posture (sitting);
state (armed);
action (cuts);
passivity (is cut).

Kant also assembled a table of categories of the human understanding, including quantity (unity, plurality, totality), quality (reality, negation, limitation), relation (substance and accident, cause and effect, reciprocity) and modality (possibility and impossibility, existence and non-existence, necessity and contingency). Russell finds Aristotle's

categories confusing. The category of substance is supposed to exclude properties that cannot exist on their own (that is, independently of a substance, for example 'white'). However, he allows a particular horse and also horse-in-general to be substances, and Russell cannot make any sense of the notion of a substance without properties (Russell 1946):

substance ... is a metaphysical mistake,
due to transference to the world-structure
of the structure of sentences composed of a subject
and predicate

Brown (Brown 1958) distinguishes between single, conjunctive, relational and disjunctive categories. In single categories, the members all have an attribute never found outside the category. An example is 'goat'. In conjunctive categories a joint presence of attributes is required (for example, a right-angled triangle). In disjunctive categories one of a set of alternative attributes is required, for instance, a lord can be a peer of the realm or a life-peer. In relational categories a specific relation is required between the attributes of that category (an isosceles triangle has two sides the same length).

4.5 Corpus origins.

As we have seen above, the semantic theory is designed to underpin a knowledge elicitation program.

The program, as it runs, builds a database of facts supplied by the expert user. However, the program is also knowledge-based in that it is supplied with a lexicon of common words. A small demonstration version of the program containing a subset of this lexicon can be found in Appendix 2.

Implicit in the lexicon is the semantic hierarchy. It is important to note that the lexicon structure is, first of all, a processing or programming aid (a bit like a road-map) and no claims are made that it (in its entirety) is isomorphic with any ontological reality out in the world.

Indeed, it can be seen that the hierarchy incorporates two distinct sub-structures, the one being composed of syntactic elements or parts of speech, and the other of semantic elements or ontological classes. This apparently unsystematic thicket is in fact merely a representation of the dual parentage (syntactic and semantic) of every word.

It will also be apparent that the higher echelons of the lattice are meta-level elements like 'adjective' and 'abstract' while their descendants are object language elements like 'ache' and 'accident'. Here are some lines from the beginning of the lexicon lattice. The code is Prolog. The ninth line,

for example, can be translated roughly as 'there is a node labelled 'one_place_predicate' and a subordinate node labelled 'adjective' and an adjective is a kind of one_place_predicate'.

```
subsumes(top,word).
subsumes(top,entity).
subsumes(word,predicate).
subsumes(word,non_predicate).
subsumes(predicate,one_place_predicate).
subsumes(predicate,two_place_predicate).
subsumes(predicate,three_place_predicate).
subsumes(one_place_predicate,adverb).
subsumes(one_place_predicate,adjective).
subsumes(one_place_predicate,intransitive_verb).
subsumes(one_place_predicate,noun).
subsumes(two_place_predicate,transitive_verb).
subsumes(two_place_predicate,adjective_plus_infinitive).
subsumes(two_place_predicate,adjective_plus_of).
subsumes(three_place_predicate,ditransitive_verb).
subsumes(non_predicate,pronoun).
subsumes(non_predicate,auxiliary_verb).
subsumes(non_predicate,interjection).
subsumes(non_predicate,modal_verb).
subsumes(non_predicate,predeterminer).
subsumes(non_predicate,conjunction).
subsumes(non_predicate,determiner).
subsumes(non_predicate,preposition).
subsumes(entity,concrete).
subsumes(entity,abstract).
subsumes(abstract,mental).
subsumes(concrete,animate).
subsumes(mental,animate).
subsumes(transitive_verb,transitive_phrasal_verb).
subsumes(intransitive_verb,intransitive_phrasal_verb).
subsumes(ditransitive_verb,ditransitive_phrasal_verb).
```

.....

```
subsumes(abstract_determiner,a).
subsumes(abstract_noun,ability).
subsumes(animate_adjective,able).
subsumes(abstract_adjective_plus_infinitive,able).
subsumes(concrete_preposition,about).
subsumes(concrete_adverb,about).
subsumes(concrete_adverb,above).
subsumes(concrete_preposition,above).
subsumes(concrete_adverb,abroad).
subsumes(abstract_noun,absence).
subsumes(abstract_adjective,absent).
subsumes(abstract_transitive_verb,accept).
subsumes(abstract_adjective,acceptable).
```



```
subsumes(abstract_noun,accident).
subsumes(abstract_noun,accordance).
subsumes(abstract_preposition,according_to).
subsumes(abstract_noun,account).
subsumes(abstract_transitive_verb,account).
subsumes(mental_noun,ache).
subsumes(mental_intransitive_verb,ache).
subsumes(concrete_adjective,acid).
subsumes(concrete_noun,acid).
```

The meta-level lines of this lexicon have been built systematically without regard for known linguistic referents. Thus, it is extremely unlikely, for example, that the node 'concrete_modal_verb' should have any descendants. This is because the lexicon is dynamic and intended for constant use and modification. Thus, new words are added during the execution of the program and branches can be pruned if they are found to be dead wood.

The object language levels of the lexicon are taken from the Longman Dictionary of Contemporary English (Longman 1987). The definitions in this dictionary are built from a restricted lexicon of common or 'basic' words which, the editors claim, are derived from all the well-known frequency lists of English words.

A word should be said about Basic English. The slightly jingoistic flavour and sporadic parenthetical exhortations to buy the audio version (£6 p&p) of the work of Ogden (Ogden 1930) and his fellows, should not lead us to deride its endeavour. While tracing its utilitarian ancestry to Bentham, the search for basic English has other forebears in the philosophy of language like Leibniz and the attempt to find a

universal language. Ogden's collection, as that of Longman, is not a frequency list but a list of 850 simple words that one can, in theory, express everything with. Longman's collection is more contemporary and serves to prune out oddities (I don't find the words 'porter' and 'whip' quite so basic as Ogden) and gives us a corpus to begin with.

Incidentally, words can be more or less basic. There are many levels of vocabulary, not just the basic and the domain-specific. If we were having a conversation about a chapter of 'The Trumpet Major' we might use specialised world-knowledge of novels to talk about it, as well as knowledge of the novel in question, Hardy, nineteenth century England and so on. There are other levels between basic English and a particular event or process or instance being described, namely sub-domains. However, for our purposes here, there is deemed to be a lexicon of basic words, common to all domains, and all other words are deemed to have specialised or technical meanings.

4.6 The grammar.

The semantics is compositional and isomorphic with the syntax. This is a simplification of the real state of affairs where words are subject to an ambient cloud of influence from the immediate and even remoter context. This does not mean such influence is not in principle measurable but that it may not be compatible with rules of syntactical composition.

A slightly less tortuous algorithm might be: the semantic class of a predicate P is a set of semantic features, being the union (this set may be without a label in the object language) of the set of semantic features of P and the set of semantic features specified for P by each other predicate N that shares an argument X with P, subject to certain conflict resolution rules.

For example, suppose the expert user typed in the sentence

buddleia_davidii outgrows weeping buddleia_alternifolia

This could be represented in Prolog as

```
outgrows(Y,X) :-  
buddleia_davidii(Y),buddleia_alternifolia(X),weeping(X)
```

or

```
P(Y,X) :- Q(Y),N1(X),N2(X)
```

Thus, the semantic class of the predicate P would be the union of its own set of semantic features with the sets predicted for it by both N1 and N2 since they both share an argument X with P, and also that set predicted for it by Q since Q shares an argument Y with P.

However, for the purposes of this semantic theory, words influence only those with which they syntactically combine.

This is according to most phrase structure and categorial

grammars, namely, an adjective combines with a noun to form a noun phrase, a verb combines with a noun phrase to the right to form a verb phrase, a verb phrase combines with a noun phrase to the left to form a sentence, a verb combines with a (non-sentential) adverb to form a verb phrase and a sentential adverb combines with a sentence to form a sentence.

We can see that, in the above sentence, P does not syntactically combine with N2, although they share an argument, and thus, for our purposes, they are deemed to exert no semantic influence over each other.

The phrase structure rules are as follows:

```

SENTENCE --> SENTENCE SENTENTIAL_ADVERB
SENTENCE --> NOUN_PHRASE VERB_PHRASE
NOUN_PHRASE --> NOUN
NOUN_PHRASE --> ADJECTIVE NOUN
VERB_PHRASE --> TRANSITIVE_VERB NOUN_PHRASE
VERB_PHRASE --> TRANSITIVE_VERB VERBAL_ADVERB NOUN_PHRASE
VERB_PHRASE --> INTRANSITIVE_VERB VERBAL_ADVERB
VERB_PHRASE --> INTRANSITIVE_VERB

```

This restricted grammar has been chosen on the assumption that most linguistic constructions have one of the following syntactic functions: adverbial, adjectival, nominal or verbal. This is similar to Rieger's case frameworks for an 'unintelligent case-frame-like parser' (Dingwall 1978).

For example, phrases such as 'yesterday morning' reduce to sentential adverbs while 'old and derelict' reduces to an adjective. Subordinate clauses such as 'after the rain had fallen' reduce to sentential adverbs and verbless clauses

('when ripe') or non-finite clauses ('being alone') reduce to adjectives.

Complements like 'in the garden' ('the Colonel was in the garden') reduce to adjectives while others ('the General's batman') reduce to noun phrases. Catenative verbs in conjunction with infinitives ('Aiglitts hates to exercise Duchess') or auxiliary verbs in conjunction with participles ('Aiglitts was thrown') reduce to verb phrases.

Disjunctive phrases ('either the General or Mrs Weobley') reduce to noun phrases and so on. Gerundives are treated as adjectives and gerunds nouns. Complex prepositional phrases can be reduced to adverbials or adjectivals (as in 'I saw the adjutant with my silver lorgnettes').

4.7 Parts of speech accepted.

All parts of speech in simple (that is unconjoined) indicative, non-anaphoric and positive sentences are accommodated by the theory, all linguistic structures being deemed to be one of the following in force: nominal, adjectival, adverbial or verbal. Here are some examples:

nominal

Shelley
the Hellespont
the blushful Hippocrene
a beaker full of the warm south
whoever loves

adjectival

green
green and white
in the green strip
behind the referee
common to all players
that Souness sold

verbal

heckles
are debating
is standing down
is putting in a good word for

adverbial

over
after
slowly
yesterday
behind the referee
at this stage in the game

While the semantic principles below apply to all linguistic constructions, the parser currently rejects the following: verbs taking a complement or more than two arguments; composite or complex noun phrases; infinitives; post-nominal adjectives ('church militant') and tensed verbs.

The analysis of adverbials is fraught. Sometimes a parser is incapable of determining scope in a sentence without having recourse to semantic information. There is a well known ambiguity in 'Blaney ate the crubeens slowly' between eating each individual crubeen slowly and eating all four slowly. In the former 'slowly' is a predicate of 'eating a crubeen'; in the latter of 'eating all four crubeens'.

Consider also 'Palgrave hired a car hurriedly' and 'Palgrave hired a car for a week'. In the former the predicate is predicated of the hiring event, while in the latter it is predicated of the result of the event. Thus account should be taken of the internal structure of the events that verbs refer to, not just of the event itself (SERC 1987). Thus a deeper analysis of verbs should be made than one that merely distinguishes them as states, activities, accomplishments or achievements.

There are methods of telling whether an adverbial is a sentential operator or a predicate operator. Fronting the adverbial can disambiguate. The opacity test states that where an adverb is a sentential modifier then it need not allow replacement of co-referring descriptions. The synonymy test states that in two synonymous sentences that do not share a predicate, for instance

Hector precedes Achilles
Achilles follows Hector

synonymy is preserved by a sentential modifier but not by a predicate modifier. It is clear that, while adverbials may be recognised by the parser and given a coarse-grained semantic classification, their semantics may be extremely complex.

Tensed verbs are also complicated: the usage of the present tense form alone is too diverse to allow anything but a trivial analysis. Here are some examples to demonstrate some of the more curious, though certainly not all, of the usages:

progressives:	e.g., Fons is undergoing the bastinado
historical present:	e.g., yesterday whom do I see but Fons
futuric present :	e.g., tomorrow Fons is in Hemel Hempstead
timeless present:	e.g., 2 and 2 are 4
:	e.g., sauria are reptiles
identification:	e.g., this is Fons
proverbs:	e.g., discretion is the better part of valour
habits:	e.g., Fons goes to the Veterinary School
headlines:	e.g., butcher eats trafficwarden
fiction:	e.g., Bert sees Fons enter the laundrette
modal:	e.g., this Mazda MX-5 goes 120 mph

The analysis of (what used to be called) the future tense in terms of modality rather than time, is also non-trivial. While the semantics of tense is an interesting question in itself, it is beyond the scope of this thesis which merely addresses itself to the question of the common semantics that the base form of a verb shares with its derivatives.

The theory applies to adjectives and adjectival phrases, although, as is well known, they can be indistinguishable from adverbial phrases, requiring a semantic disambiguation. It is claimed adjectives can be intersective or non-intersective. This may be a convenience. The intersection of 'red' and 'hair' might yield 'red hair' but the intersection of that same set 'red' and 'rose' would yield not only red roses but also ones which were that pale apricot colour that red hair so often is. These are not usually called red roses. Black tulips might also slip the net as being exemplars of blackness. Thus, 'red' may be almost as non-intersective as 'former', 'fake', 'good' and 'big'.

Even apparently troublefree adjectives like 'male' have

multiple entries in the dictionary, between which there is only an obscure metaphorical connection (Chambers 1983):

appertaining to the sex that begets not bears young;
having botanical stamens;
having mechanical projecting parts;
male orchis: the early purple orchis;
male order: the Doric order in architecture;
male rhymes: those in which only the final syllables
correspond;

It is not clear whether there are any genuine intersective adjectives. The procedure of intersection seems odd anyhow. We do not assess how good an example of a red object an apple is before we pronounce on its redness. This is, of course, merely a psycho-linguistic observation but it seems no coincidence that we do not, as Wittgenstein realised, compare yellow objects to a patch of yellow in our heads to see if they match. We rather recognise an object, say, an apple, and recall that this is the sort of apple we call yellow.

Adjectives can also be sortal or substantive, for example:

African elephant (the species African elephant)
African elephant (an elephant bought or reared in Africa)

Idioms are a problem. They are characteristically non-compositional. This is exhibited in the anomalous

it's raining cats and dogs: no, sorry, it's only raining cats.

They must be distinguished as lexically irreducible or inference will be mistaken. We can distinguish between idioms proper, where the whole does not equal the sum of the parts,

for instance

spill the beans

and partial idioms, where the whole equals part of the sum of the parts, for instance

the White House
field mouse
black poplar
white coffee

A large number of phrasal verbs fall into one or other of these categories. They are best held as entities in a lexicon for this reason. Nearly all the following adverbs can be used in conjunction with the first thirty or so verbs on a frequency list, some yielding non-compositional (idiomatic) meanings:

about, back, inside, outside, beside, until, after, before, upon, aside, at, of, off, up, down, through, around, round, between, behind, on, in, under, with, by, from, out, to, throughout, over, near, away, within, for.

Some examples, illustrating the non-compositional nature of phrasal verbs, are:

I'm going to look round the necropolis
I'm going to see Dibber about the onion sets
I'm going to look up Bunt

The first example could be deemed compositional since 'round' can mean 'all over' as well as 'beyond' (for example, 'I'm going to look round the corner') (Chambers 1983).

The second and third are less straightforward: for one thing, they could be spoken meaningfully by a blind man. This, in

itself, however, does not render them non-compositional. The injunction

see Birkin about sending more ericacious potting compost

could probably be executed by a telephone call. However, the reason for this need not be that the phrasal verb is more than the sum of its parts. It may just be that both 'see' and 'about' have secondary meanings, say, 'make contact with' and 'concerning'. Of course, this explanation falls down if these two senses of 'see' and 'about' fail to crop up anywhere except in this particular phrasal verb.

Prepositions, while not themselves possessing any of the four main grammatical functions, nominal, verbal, adverbial or adjectival, nevertheless occur with high frequency, and must be accommodated by any semantic theory.

The current thesis is only concerned with words of high frequency according to the above named frequency lists. While verbs are cited in the infinitive in these lists (all forms being conflated into one entry) other parts of speech have a separate citation for each form. Thus, in this work, shared inferences from paronymous terms will be restricted to verbs.

Chapter 5.

A semantics of prediction and coercion: Grounds for a semantic principle.

5.1 The disambiguation of senses.

As was stated above, the current research has three aims:

- to make inferences from computer input information to acquire more information,
- to predict the meaning of unknown words from known ones in adjacent text, and
- to predict the semantic category of linguistic constructions from their components.

A semantic principle is required for the latter two of these aims because of the widespread use of metaphor, category mistake, 'sense-shifting', call it what you will. Natural languages are hugely ambiguous, unlike computer languages whose ambiguities are solvable locally. A principle is required for the disambiguation of senses.

The best known example of a word whose sense shifts in context is 'good', one of the least intersective of all adjectives. Roughly speaking, good adults are moral, good babies quiet, good doctors and engines are efficient, good parties are pleasant, good flour is pure and so on.

There may be many reasons why a word varies in context. It may be a non-intersective adjective as we have seen with an elliptical meaning (compare, healthy body, healthy exercise,

healthy complexion). A word may be used metaphorically: the foot of a mountain only shares part of its sense with the foot of a man. A word may be part of a complex noun phrase with a highly context dependent meaning (for instance, air raid shelter, bus shelter).

It is worth mentioning the syntagmatic/paradigmatic distinction (one of the Saussurean dualisms) as a sub-division of linguistic semantics because this has a bearing on entailment. One can think of a word when it is in context as having (at least) two dimensions, the linear one, namely its sentential position, but also its position in some kind of conceptual structure. Cruse (Cruse 1986) suggests the significance of these two dimensions:

Paradigmatic relations...reflect the way infinitely and continuously varied and experienced reality is apprehended and controlled through being categorised, subcategorised and graded along specific dimensions of variation. They represent systems of choices a speaker faces when encoding his message. Syntagmatic aspects of lexical meaning on the other hand serve discourse cohesion, adding necessary informational redundancy to the message, at the same time controlling the semantic contribution of individual utterance elements through disambiguation, for instance, or by signalling alternative e.g. figurative strategies of interpretation.

Some have touched on the importance of the disambiguation of senses in other contexts. Hall-Partee (Dingwall 1978) says:

The different sub-senses of 'remind' are clearly closely related and only one of them is equivalent to 'strike as similar'. It remains to find a way to reconcile the two kinds of generalisations, one among distinct lexical items that share distributional and semantic properties and the other among semantically and/or syntactically differing uses of what seems

nevertheless to be a single lexical item or a family of morphologically closely related items.

Rieger (Dingwall 1978) says:

we will argue that, if a model has the ability to organise word-senses, then use this organisation to discriminate and identify uses of a particular sense of each word of each sentence in some context ... then that model has the primary mechanism of language ..most of the complexity in natural language, in fact most of its information content, lies in the individual word sense rather than in any central or uniform system of rules.

Rieger thinks that all the questions we may ask in order to discriminate senses fall into one of the following classes:

- 1) questions about adjacent words;
- 2) questions about the syntax or semantics of adjacent word senses;
- 3) questions about invariant general knowledge;
- 4) questions about dynamic expectancies in the model.

Rieger's system is concerned with words with many senses but does not address itself to conflict resolution or what should be done when two words are in a close syntactic relation such as a predicate and its argument ('Grogan shifted') or a head and its adjunct ('feckless Grogan') but appear to conflict semantically (for instance, 'thirsty bucket').

It seems that some or all (severally) components of a word are cancellable in context, and that some kind of semantic principle is required to characterise this.

5.2 Lack of a systematic lexical semantics.

The second reason why a semantic principle is needed is that principles and theories of word meaning are rare. In a post-Fregean scientific age linguistics and semantics are increasingly theoretical. That part of semantics that concerns logical or structural meaning and resides in function words and logical operators is amenable to this approach but general word meaning or lexical word meaning is more elusive and thus has been, to some extent, neglected except by lexical scholars like Cruse and also knowledge representation practitioners in artificial intelligence. Thus a lexical semantic principle is required.

5.3 Inadequacy of selectional restrictions.

Another of the grounds for a semantic principle is the inadequacy of selectional restrictions. We have seen that, roughly, formal semanticists have undertaken the task of characterising logical entailments while descriptive linguists have characterised lexical ones. However, we might ask whether entailment is the most fundamental linguistic mechanism at all? Perhaps linguists have fallen into a formalist trap to suppose this to be so? Another way of exposing lexical entailments, if they are there to be exposed, is by considering the violation of selectional restrictions or 'what we cannot say'. This phenomenon is also variously named type-crossing, category mistake (Russell 1946) and violation of integrity constraint (Gray 1986). It was first alluded to by Aristotle, when devising his categories (Ackrill 1987).

A predicate in one category might, in certain conditions, and on account of its category membership, be thought inappropriate to apply to a subject in another.

For Ryle, when an expression cannot be substituted for another without turning meaning into absurdity there is a category mistake. His definition of absurdity is generous, believing that good syntax plus category mistakes can lead us to believe in entities that do not exist. Presumably this would include

I saw Eternity the other night:
Like a great Ring of pure and endless Light,
All Calm as it was Bright...

Still round and round the Ghosts of Beauty glide,
And haunt the Places where their Honour dy'd...

For Cruse, semantic traits are presupposed by selectors which occur in constructions in which co-occurrence restrictions are operating. In a head-modifier construction it is the modifier that is the selector. In a head-complement construction it is the head which is the selector. For example,

'a pregnant X' entails X is female,
'X drank Y' entails, among other things, that Y is liquid,
'X died' entails X was alive.

Cruse defines selectional restrictions as 'those presuppositions of a selector whose non-satisfaction leads to paradox or incongruity'. He suggests that we can distinguish between

- selectional restrictions, that is, logically necessary semantic co-occurrence restrictions, for example, 'die' presupposes features 'organic', 'mortal', 'alive' and so on, and
- collocational restrictions, that is, arbitrary co-occurrence restrictions for example, 'kick the bucket' presupposes a human organism; 'toasting' can be done to bread, 'grilling' cannot; they are irrelevant to truth conditions but odd; their presence alone does not undermine cognitive synonymy.

This is controversial. 'Die' and its derivatives are, in fact, quite versatile ('the engine died'; 'the day the music died'; 'is this glass dead, pal?'). Idioms like 'kick the bucket', on the other hand, seem to me to correspond more to a general principle concerning any kind of linguistic phrase, namely that it is less amenable to metaphorical usage than an individual

word would be.

Thus, we might say that a theory was rebarbative but probably not that it has spiny filaments growing out of it. Likewise we might say 'Hippolyte is a pig' but probably not say 'Hippolyte is an omnivorous ungulate with a thick bristly skin'. This is not merely because we cannot summon up some lengthier paraphrase of 'pig' or 'rebarbative' but because phrases tend to be more specific and less amenable to metaphorical usage.

It is a curious fact about linguistics as with other quasi-scientific subjects that formalists and libertarians jostle under the same banner while their intellectual positions are incompatible. On the one hand, it is often claimed that linguistics is not prescriptive but descriptive, that a linguist cannot assume the pedagogic mantle of a nineteenth century grammarian. On the other hand formalists seek a calculus or a formal method which characterises language and prescribes and proscribes its use. Aitchison (Aitchison 1978) says

it is a common fallacy that there is some absolute standard of correctness which it is the duty of linguists to maintain.

This 'fallacy' must however be implicit in the work of both syntacticians defining, for example, a comprehensive set of phrase structure rules and linguists like Chomsky defining universal linguistic constraints.

It may be argued that this endeavour is not so much

prescription as an attempt to characterise what is conventionally or humanly possible. Thus, linguists seek to outline not what we ought to say but what we do say, the *de facto* not the *de jure*.

This does not seem to me to be true. There is nothing to stop me uttering syntactic gibberish. In this way, language is quite unlike any other natural phenomenon: there is plenty to stop me falling uphill for instance and I haven't a choice in the matter. What then is being claimed? It is wrong to say linguists characterise what is humanly possible. At most they characterise what is customary and conventional. However this is the same as prescription. Prescriptive laws prescribe behaviour appropriate to a moral or social system.

What has this got to do with selectional restrictions?

It may be argued that it is possible to formalise and prescribe in the field of syntax but, as far as semantics goes, Aitchison is right and we cannot dictate. What then of selectional restrictions? Does 'pregnant' entail 'female'? A pregnant moon is only female in a metaphorical sense. It is certainly true that entailments are often preserved at a metaphorical level, although both antecedent and consequent are construed metaphorically, but it is not always the case. The point about metaphorical usage is that it is selective. Some features are chosen: some are not. In

as Vernon sank he breathed in pond water;
eventually he fought his way up and drank the pure air

'drank' obviously does not entail that 'air' is liquid. The relevant features of 'drank' in this context concern eager gulping and savouring of something or other but it does not seem right to say that the pure air is even metaphorically liquid. On the contrary, the entailment seems to work in the other direction: the direct object 'air' circumscribes the meaning of the verb 'drink' in the way just mentioned.

Some people are very anxious to adduce examples of selectional restrictions for completeness sake but fail to provide convincing ones. Katz (Katz 1971b) cites

waterproof shadows empty foolishly

as an example of 'meaninglessness' and 'open/close' and 'whisper/shout' as incompatible pairs. This is extraordinary. He says we have a

linguistic intuition that... the sentence
"the shadow...fell from the 53rd floor and broke
both itself and the pavement when it landed" is
semantically deviant...

Katz is indeed correct when he says the following.

If we count the number of senses that the lexical items of an ordinary 15 or 20 word sentence has and compute the number of possible combinations that can be formed from them when they are paired up, in accordance with the grammatical relations of the sentence, the number of possible senses of the sentence runs into the hundreds. Since no sentence of a natural language has anywhere near this number of senses and some have none at all there must be a rather severe form of selection going on...

Katz, following the long tradition springing from Aristotle,

claims that words are categories and that

the category of a concept specifies the other concepts with which it can combine to assert something of some object in its range of predication.

Is this the only solution to the apparent paucity of sentence meanings given the combinatorial possibilities? It seems rather the case that words coerce and filter one another. The semantic features or components are filtered if necessary and if there is still a conflict one feature must over-ride the other. Katz claims shadows cannot be waterproof because waterproofedness involves the inside of an object and shadows haven't got insides. This is tendentious. Shadows have got area and thus insides: moreover waterproofedness can be applied to ink which may have even less of an inside than a shadow.

One source of category mistakes is what Cruse calls incompatibles. Mutually exclusive classes are indicated by incompatibles, that is, there are two terms X and Y where 'A is an X' entails 'A is not a Y', for example

'Sceolan is a man' entails
'Sceolan is not a woman',
'Great-bladdered Emer is walking' entails
'Great-bladdered Emer is not running',
'Cuchulain is near the building' entails
'Cuchulain is not in the building'.

Entailment is of course unidirectional.

'I met Bran today' does not entail
'I did not meet Bran yesterday',
'Oisín bought some apples' does not entail

'Oisín did not buy some pears',
'Niamh's eyes are blue' does not entail
'Niamh's eyes are not red'.

Cruse points out that co-ordination can suggest incompatibles, but is not reliable, for example, 'I met students and bank managers and election candidates'. Here however I would suggest that the co-ordinate coerces incompatibility. It is true that being a bank manager is not mutually exclusive with being a student but I think what is intended by the speaker is a classification of people according to their primary occupation. It seems to me that the context has restricted the terms used (student becomes full-time student) not that the co-ordinate has lost its exclusive power.

If one can claim that Mary's eyes can be blue and red, then perhaps one can also claim that one can be running and walking or that one can be in and near a building. Part of Mary's eye is blue and another part is red. Likewise I could be running for a moment and then walking, or be near the house with my head through the window. Cruse is certainly right to claim one cannot be walking and running simultaneously or wholly in and out at the same time but a Gricean audience would provide some elliptical gloss to nullify the violation and redeem the sense:

I was inside and near the house all day in case Trimble rang
Trimble was walking and running alternately to rest his toe.

Thus it may be that while we can talk of selectional preferences, selectional restrictions at best only operate in some contexts and in others they are violated by metaphor,

irrelevant or false. The way words circumscribe each other is more complicated than this, as is suggested later.

The desire to uncover a general semantic principle of selectional restrictions is so strong that we may be tempted to proscribe usages that are perfectly acceptable to everyone. The search for a theory is, as Wall (Wall 1978) says in another context, like the man who searched for a penny under a streetlamp. He had dropped it down the road but was looking for it there because the light was better.

It has been suggested that the study of selectional restrictions will uncover some

empirical basis for the distinction between arguments and non-arguments, the idea being that a verb will have selectional restrictions on its arguments and not on anything else (Riemsdijk 1986).

Thus "seems" would not take the subject of the sentence as one of its arguments though a verb embedded under it would. As we will see later, the special relationship between a verb and its arguments is reflected in the semantics although in a more complex way than the mere imposition of selectional restrictions.

A general point should be made. It is not enough to say something is a 'category mistake' or 'breaches a selectional restriction'. If someone said to Grice, 'Is that your elbow in the butter?' he would not say under his breath 'Fool!: whose elbow would you expect to find attached to my hand?' but

would construe the 'question' accordingly. This is true of solecisms in every area. If Matisse paints a picture which appears to be an unruly daub and we know he is capable of photographic execution we will ask ourselves why he has deliberately painted this way. (This is true independently of the worth of the picture.)

To claim that exceptions to the rule are always errors is as foolish as trying to generalise from them. It would be rather like saying that because you had to eat the pilot in the Amazon to keep yourself alive then cannibalism is alright in Bishops Stortford. Irregular behaviour in all walks of life is neither normative nor always pathological but just irregular.

Likewise, although one might correct a child who said 'I have eaten the ice cream' or 'the tree smiled', we would have a different attitude if a poet or any adult said such things.

A deliberate category mistake is not meaningless any more than some speech acts are, but is a purposeful violation. One might dub this phenomenon, after Putnam's division of linguistic labour, as the division of linguistic responsibility. Pope was aware that some men of letters are 'above the law' in this way (Pope 1709).

Great minds do sometimes gloriously offend
And rise to faults true critics dare not mend

Interestingly, although little minds are presumably not above the law, nevertheless, the most infelicitous solecisms are

rarely meaningless, such as the advertisement for hormone face-cream, toothsomely called Plenitude Action Liposomes, which claims 'they make your face feel visibly younger'. This is, in fact, merely one of the most common kinds of ellipsis, being ellipsis of 'as if it were'. Compare 'my face feels red'.

It should also be said that metaphor violates selectional restrictions and the ubiquity of metaphor precludes us from relegating it to the study of pragmatics, a tempting home for everything meaningful that will not fit into our favourite semantic theory. Sentences such as

he read widely on the issue

are metaphorical in a purely lexical sense not a pragmatic one.

I believe that the best candidates for genuine category mistakes involve modality and tense. These are often believed to be very closely related as is demonstrated by the curious ambiguity of

I will see Venice and die

and the schoolmaster's pedantic joke

I shall die and no-one will save me.

The ambiguity of the former possibly depends on the choice of a mere future tense reading or one involving psychological intention. The latter example is an attempt to disambiguate just this problem for schoolboys and it is not insignificant

that, nowadays at any rate, its import can be missed. Compare the very rough synonymy of

this bed is collapsible
this bed will collapse

Tense is also closely bound up with philosophical notions of freewill and determinism. Dahl (Dahl 1985) says

Normally, when we talk about the future, we are either talking about someone's plans, intentions or obligations, or we are making a prediction or extrapolation from the present state of the world. As a direct consequence, a sentence which refers to the future will almost always differ also modally from a sentence with non-future time reference.

It is an intuitively appealing idea, not just to the curiously paradoxical Calvinists, that, in some sense, the past could not have been other than it was. Sometimes this belief is extended to include the assumption that the future cannot be other than it has always been predestined to be. At the same time men feel themselves to be autonomous and responsible for their actions. However, there is a class of mental processes that seems curiously out of tune with this belief. This can best be demonstrated by some examples that seem to embody some kind of category mistake:

this catastrophe motivates a need for better community policing
Father Blaney decided to want a doughnut
Gloria decided to know that she had chicken pox
Father Blaney chose to need a new soutane
Father Blaney decided to understand the abbot
Wingco Gosh Fairbanks decided to forget the incident
Father Blaney made up his mind to believe in transubstantiation
Sir Bigshot Bagott decided to think that the boy was lying
I decided to ponder on the matter
Hippolyte decided to regret the deed

Wingco Gosh Fairbanks decided to remember his mother
Father Blaney determined to lack longjohns
Hippolyte decided to long for rissoles
I decided that the thought would occur to me
Sir Bagshot Bigott resolved to feel pain

The last example is realised even more preposterously in
Dickens' *Hard Times* where the ailing and chronically
self-effacing Mrs Gradgrind remarks that she is sure there is
pain in the room somewhere but she doesn't know whether she
has got it.

Some of the above examples are acceptable or elliptically
acceptable. We can decide to ponder on and think of things.
Likewise, we can decide to forget something in the sense that
we can order our actions in such a way that we are prevented
from dwelling on something. This is not the same however as
being able to marshall our thoughts instantly or at a
preappointed time.

We can also decide to decide provided that this means we are
deciding that we will decide at some future time rather than
that we are deciding that we are deciding. We can also decide
that we must be deciding but this reflexive stance places us at
a remove (to all intents and purposes a temporal remove) from
our decision. Thus, it is broadly synonymous with 'I decided
that I had decided' or 'I realised that it (the decision) had
happened to me'.

These examples apart, it appears that our minds are rather like
children. We can train them up in the way they should go and

after that they are free to believe, regret, covet and so on without waiting for our permission.

It seems that we can reflect on the past or the future but not the present. Thus, I would claim that sentences such as

Father Blaney decided to know he was bald

are category mistakes in the same way that

I will see the chiropodist yesterday

is. Compare also the last line of this poem by Norman MacCaig (MacCaig 1985).

Ask me, go on, ask me
to do something impossible,
something freakishly useless,
something unimaginable and inimitable

like making a finger break into blossom
or walking for half an hour in twenty minutes
or remembering tomorrow.

Category mistakes, so-called, dislocate our thought processes disturbingly, like spelling mistakes, or exhilaratingly, like Escher's impossible pictures, depending on our attitude. They are not the only kind of anomaly however that can trip us up.

It is clear that, since selectional restrictions appear to be so much less restrictive than we thought, that we need a principled way of interpreting the 'anomalies' selectional violations produce. However, a semantic principle of disambiguation, as well as addressing category mistakes, should address what one might call prototypicality mistakes.

For example,

I live in a jamjar

if asserted truthfully by a healthy man is anomalous. There is no category mistake. The verb 'live in' denotes a physical state which can compatibly obtain inside a physical object. Of course the problem is that the typical jam jar is too small for a person to live in. Either the sentence means that I spend a lot of my time with at least part of myself or maybe my spoon in a jamjar, or that I live in a dwelling that has some of the properties of a jam jar (lots of windows, for instance) or something highly metaphorical, perhaps that the people I live among have some resemblance to fruit preserve. Such a sentence could be called a prototypicality mistake in that, while no categories conflict, nevertheless, the prototypical realisation of a word in the sentence is absent.

Prototypicality mistakes shade into category mistakes at one point. We may even feel that the idea of categories is unhelpful. This was Russell's view in The History of Western Philosophy (Russell 1946).

What exactly is meant by the word 'category' whether in Aristotle or in Kant and Hegel, I must confess that I have never been able to understand. I do not myself believe that the term 'category' is in any way useful in philosophy, as representing any clear idea.

It is indeed hard to be precise about the pathological differences between

that woman is a bachelor

and

I ate the Sydney Opera House.

Here are some other examples that obfuscate the distinction between category mistake and prototypicality mistake further and demonstrate the varied causes of anomaly.

yuoi sdgfhfolu h sedrg i gfhlk	orthographical
Vera love I	syntax

soldiers is handsome	syntax
Arthur and Alf and Stan are both masons	plural/dual

the windowcleaner is former	attributive/predicative
the gardens are hanging	attributive/predicative
this elephant is African	sortal/substantive

that was the worst success	negative/positive
all men are mortal but that man isn't	propositional calculus
Sopwith and Venables are rusticated and Sopwith isn't	propositional calculus

Venables is happy and unhappy	logical
Logan knows an untruth	logical
Venables is neither married nor unmarried	logical
Sopwith is doing it again for the first time	logical
Arthur regrets doing something he knows he didn't do	presupposition

the dog is in the larder and I don't believe it	epistemic
this sentence is false	reflexive
the nude in puris naturalibus lit a Rothman's	tautology

I came there to see Jennings	deixis
Botolph paused widely	spatio/temporal
I will do it yesterday	temporal
I decided to understand him	modal

I will have a gin	count/mass
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my scottie doesn't bark	prototype
Meaulnes poured the butter out	prototype
I live under that pebble	prototype
there's a human goat	hyponymy
Ambrose is a man and a woman	incompatibles

that genius has mastered long division	irony
it's unfortunate that Fons died from the pilliwinks	litotes
he took offence and his gamp and left	zeugma
I drank a cup for breakfast	metonymy
I am a greater thinker than Wittgenstein	hyperbole
the damsons have a bitter sweet taste	oxymoron
he is reading the whole of Clarissa	perfective/imperfective
he climbed to the top but didn't get there	perfective/imperfective
Arthur flinched slowly	progressive/achievement
Reg hardly died	progressive/achievement
Fred suddenly lived in Morpeth	stative/active
he is very deceased	gradable/non-gradable
he is rather alive	gradable/non-gradable
Alf tiptoed noisily into the vault	lexical
he painted the walls with silent paint	lexical
the shadow broke across the lawn	lexical
Arthur smells itchy	lexical
I feel visibly younger	lexical
Biddulph thought noisily	lexical
she is an iron lady	lexical
it is a tin soldier	lexical

It should be clear from these examples that there are many reasons for semantic anomaly. However, it seems that, apart from morphological eccentricity, all other kinds of semantic anomaly can be classified as some kind of category mistake. Even logical anomalies of the P and notP kind could be regarded as a co-occurrence of the categories positive and negative.

Broadly speaking, the dearth of genuine selectional restrictions is slightly intoxicating. We can say anything provided it is not too ungrammatical. This may not be a surprise to anti-formalists but to architects of semantic theory it is disturbing. In what sense can one have a theory of lexical composition if words are so promiscuous?

I propose that what we should be seeking is not an account of selectional restrictions or category mistakes but an account of selectional preferences and a principle of disambiguation or arbitration amongst the possible meanings a linguistic construction can appear to have.

5.4 Inadequacy of meaning postulates.

We have seen that there are a number of reasons why we need a principle of semantic disambiguation. One is the high incidence of words with multiple senses; another is the virtual absence of systematic lexical semantics; a third is the resilience of meaning in propositions that embody category mistakes or selectional restriction violations.

A further and related reason is the inadequacy of meaning postulates to predict the meaning of unknown words or the senses of ambiguous ones.

Carnap devised meaning postulates to state relationships between certain meanings or intensions (Carnap 1937) or, more precisely, to represent analytic sentences in a formal language. Here are some examples.

if x is crimson then x is red
if x buys y then x pays money in order to own y
if x kills y then x causes y to become not alive

These are examples of analytic truths but there is no reason why meaning postulates should not represent synthetic truths if they are useful for a particular purpose. Indeed Quine (Quine 1960) could not really see the difference. It is certainly true that in an artificial domain like a database we could dictate that, for instance, all employees have a serial number by definition. Thus so-called synthetic meaning postulates like the following may be useful too.

if x is an endowment policy then x has a date of maturity
if x is green then x is extended
if x is buxom then x is female

It can be seen that these meaning postulates have a measure of analyticity that is absent in truly synthetic propositions like the following.

if x is endowment policy EW18493875 then x has a date of maturity of 30.09.2010

The flexibility of meaning postulates may suggest that they are useful devices, if not for expressing constraints on models, nevertheless for expressing default relationships between words. However, meaning postulates are not adequate to express the lexical relations between words. Consider, for example, the following.

swallow(x,y) -> physical_substance(y)
drink(x,y) -> liquid(y)

The problem with these two meaning postulates is that (unless they are considered merely as default statements) they proscribe valid usage like the following.

Vernon swallowed the lie
Vernon drank the pure air

Such usages are not, contrary to popular linguistic belief, florid, poetical, rhetorical or in any way self consciously precious. We probably would not even notice anything semantically anomalous about them. If one is still in doubt there are even more prosaic examples.

Walters is deeply worried about the fingerprint
Souness ruled out chemical weapons
McCoist pointed out the structure of human existence as the
framework within which questions have to be posed
Butcher showed that this is the dimension that has to be faced
Drinkell had narrow interests, a cold manner and a dry wit
McStay sang a high note
Stevens went to the foot of the building
there is ample evidence that great empires rose and fell in
India

The following example comes from Whorf (Whorf 1956) as an
illustration of how spatial terminology is frequently used to
refer to psychological matters.

I grasp the thread of another's arguments but if
its level is over my head, my attention may wander
and lose touch with the drift of it so that when he
comes to the point we differ widely, our views being
indeed so far apart that the things that he says appear
much too arbitrary or even a lot of nonsense.

Context dependence is not restricted to indexicals or non-
intersective adjectives. Other words (for instance, drive the
car, drive the cattle) depend on context of use. Some people
have gone so far as to suggest that the pragmatic/semantic
distinction should be abandoned (Eikmeyer 1981).

Sometimes a whole lexical field is shifted into metaphorical
usage. In European languages it is customary to discuss time
and also intensity and tendency in spatial terms, for example,
long day, high intensity, tendency to rise and so on. (This,
interestingly, is different from Hopi where time has a
vocabulary of its own that is not used in spatial description
(Whorf 1956).) This creates problems for a systematic
semantics since it is unclear whether 'long' as in 'long day'

is a metaphorical usage, a secondary meaning or neither.

Whichever it is, our semantics must accommodate it. A meaning postulate of the following kind

if x is long then x is physically extended

would be no good.

The longstanding awareness of the existence of metaphor makes it surprising that some linguists still support the idea that meaning and entailment are just a matter of semantic components and selectional restrictions (Locke 1690):

....to imagine, apprehend, comprehend, adhere, conceive, instil; disgust, disturbance, tranquillity etc. are all words taken from the operation of sensible things and applied to certain modes of thinking.

As Sampson (Sampson 1980) says, metaphor is far more common than we think but is left out of compositional semantics.

Others believe semantics to be too vague to establish immutable semantic rules (Eikmeyer 1981):

meanings are not fixed objects of any sort, they are fuzzy, flexible and open to adjustment. Secondly, the use of meanings is closely linked up with the fact that contexts may be continuously changed.

Thus language is vague essentially not marginally.

What does it mean to say that a term is vague?

Kempson (Kempson 1977) distinguishes four different types of vagueness:

- referential vagueness: the meaning is clear but it is unclear whether it can be applied to certain objects, e.g., town and city;
- the meaning of the word itself is indeterminate, e.g. 'Bim's' in 'Bim's book' can mean one Bim wrote or owns etc.;
- clear meaning but lack of specification, e.g. 'neighbour'; 'went' as in 'Vernon went to the station' covers many different modes of travel;
- disjunction in meaning caused by 'or' or negation, e.g. 'Vernon can mend sinks or washbasins', is unspecified on two levels; for one thing 'or' is used to cover the logical exclusive-or and the logical inclusive-or, but even if there were only one kind of 'or', say exclusive-or, the sentence would still be vague as we still don't know whether it is sinks Vernon can mend or washbasins; similarly with negation, because of de Morgan's law ($\text{not}(X \text{ and } Y) \rightarrow (\text{not}X \text{ or } \text{not}Y)$); this is not ambiguity but under-specification.

Thus metaphor, contextual coercion and inherent vagueness all militate against the characterisation of a body of reliable meaning postulates.

Determining meaning postulates is in any case an arbitrary endeavour. The meaning of words is not an exact science and thus defining words in terms of others, whether for paraphrasing, synonymy, hyponymy, antonymy, entailment relations or any type of meaning postulates must be an imprecise activity. Indeed some think it a misplaced endeavour and only provisional. For the philosopher Quine, the empiricist point of view could not make sense of the notion of equivalence of meaning which is required by reductionist semantic programmes like that of Carnap (Quine 1953).

Pinning down the relations between words seems much easier in theory, perhaps because of the widespread existence of

dictionaries, than it is in practice. The circularity and vagueness of lexical definitions is hidden under the specious orderliness of dictionaries. Winograd (Winograd 1976) has some nice examples of men that might or might not qualify for the status of bachelor depending on one's point of view (the Pope for instance), despite the received wisdom that 'bachelor' is one of the most precisely defined words in the language. It appears it is a family-resemblance type concept rather than a set-intersection type.

Fillmore (Fillmore 1982) argues that lexical concepts are represented in terms of idealised cognitive models. For example, 'bachelor' can be defined as an unmarried adult male, in the context of a society in which certain idealised expectations of marriage obtain. The existence of Catholic priests, male homosexuals and co-habitees does not mean that the concept is ill-defined but that it doesn't fit the world precisely. Mohr (Mohr 1977) suggests we view Platonic universals in this way. Compare Lakoff (Lakoff 1972).

According to Fillmore's view the connection between concepts and exemplars is comparable to the connection between theories and data. Theories are simplifications: data is unruly. As Kuhn (Kuhn 1962) argues, theories depend on a background of assumptions; thus concepts also depend on background assumptions about the world (Fillmore 1982). We do not always recognise these assumptions, and are blithe about generalisations like 'a cheetah can run faster than a man',

disregarding arthritic cheetahs and baby cheetahs (Ziff 1960). The unspecified set of conditions under which this claim about cheetahs is true, Ziff calls a conceptual schema, and people understand one another to the extent that their conceptual schemata are shared. We can see that this problem is closely akin to the frame problem or the qualification problem, namely, to what extent must a concept and its context be exhaustively defined. Concepts can end up like God, in the atheistic philosopher Wisdom's phrase, 'dying the death of a thousand qualifications'.

Concepts are fuzzy, instantiated by exemplars, that is abstract entities 'representing a conflation of typical properties' (see Fillmore 1975, Rosch 1975 and Wittgenstein 1953). The exemplar chosen in a discourse will, if possible, be one that satisfies all the current goals set up. This means that meaning postulates can only be formulated if one identifies which exemplar of the antecedent is the relevant one.

Meaning postulates may also fail in the context of 'hedges' (Lakoff 1972) or linguistic disclaimers, for example

Arthur's wife is such a socialite that he is a regular bachelor.

Others find meaning postulates, or any kind of formal representation technique, inappropriate. Dictionaries can only give approximate non-definitive accounts of word meaning (Sampson 1980); it is a dogma of linguistic semantics that words have essences or criterial features; they only have

'increments of probability' (Labov 1973) or entailments with weightings (Labov 1972).

Grice (Grice 1978) distinguishes between the derivative and non-derivative senses of words. For instance the words 'loose' and 'unfettered' may appear to be synonyms but in the expressions 'a loose life' and 'an unfettered life' the former takes on a derivative sense (that is, implying dissipation) while the latter seems quite general in meaning.

5.5 Inadequacy of feature unification.

Another reason why semantic principles of prediction and resolution are needed is the inadequacy of feature unification. An important mechanism used for the representation of meanings is the feature-based formalism. We have already seen that there is a long tradition of analysing meaning in terms of components, features, sememes, atoms, whatever one likes to call them. Just as a word has definitive features that circumscribe its meaning ('spinster' has 'single') so they also place strictures on the meanings of that word's neighbours in the sentence.

Thus, unification of features purportedly enables one to disambiguate polysemy, for example,

Father Blaney read the bible

Here 'bible' would be resolved as a religious book, not a cow's

stomach, because of the selectional restrictions 'read' would impose.

However, while this technique is successful in some cases it is not always so. Unification of features cannot account for the resolution of all semantic anomalies since it cannot determine whether the verb phrase

swallow the lie

denotes a physical action or a non-physical one, and it must logically be one or the other, and, moreover, we know which. 'Lie' (as in 'deliberate untruth') has some sort of feature like +abstract. 'Swallow' would be +physical. There is no principled way of achieving feature unification here. Thus a principle is required to resolve this.

5.6 Inadequacy of semantics of syntactic government.

A further reason why semantic principles are needed is that theories of syntactic government cannot account for the resolution of semantic anomalies, since they cannot account for the fact that both of the following examples denote non-physical situations, while one has a physical verb and a non-physical object noun and the other vice versa.

Father Blaney put his finger on the problem
Father Blaney's condition justified the bucket

An important claim made by the theory is that anomaly

resolution cannot be derived from syntactical structure, head-modifier structure or government and binding structure.

Various grammars have differed in their analysis of heads and modifiers but have agreed on the basic principle that they are derived chiefly from syntactic structure not word meaning (with some exceptions, for example, an adverb can only be disambiguated as sentential or verbal by virtue of word meaning).

A purely syntactic notion of what a head and a modifier are seems to have been extended to a semantic one. In syntactic research it is believed that, using tests of transposition, substitution and so on, phrases can be identified. Within each of these phrases a central constituent can be found called the head (for instance, the head of a noun phrase is a noun). The following criteria to be used for recognising heads have been suggested:

- they are characteristic;
- they are obligatory;
- they control the agreement and number and type of constituents within the phrase;
- they control constituents outside the phrase.

Modifiers are defined as 'everything in a constituent that is not the head', for instance, the parenthesised words

the book (that fell into the cuspidor)

Modifiers are distinguished as peripheral or nuclear, dependent on the strength and closeness of the link between them and the

head (for instance, the complement of a verb is very strongly and closely related to it). Thus, Reed and Kellogg's nineteenth century sentence diagrams and Tesniere's dependency grammar of the 1950's would both agree that adjectives modify nouns.

There are, it is said, heads, adjuncts and arguments. In the phrase 'sleepy Alf', 'Alf' is the head and 'sleepy' is an adjunct, while, in the sentence 'Alf slumbers', 'slumbers' is the head and 'Alf' is the argument.

Another way of expressing it is as follows. If X is the head then if

$X + Y = X$, then Y is an adjunct;
 $X + Y = Z$, then Y is an argument.

Do adjectives always modify nouns? It seems that this is a doubtful claim in the following examples,

the iron lady
the good president

where the adjective and noun both modify, or affect the interpretation of, each other and, in the first example, the adjective is coerced by the noun. The truth of Winograd's (Winograd 1983) claim that

the concept of modification corresponds well to our intuitive notions of description. A noun tells what an object basically is, while adjectives provide further description

seems to depend on the noun and adjective in question too (think of 'tin soldier'). The following set of examples

illustrates how our basic inclination to recognise nouns as heads can be overturned by semantic coercion.

wet bucket
jogging bucket
forlorn bucket
thirsty bucket
contrite bucket
human bucket
invisible bucket
imaginary bucket

Buckets can be wet; they can even jog under external influence. Their appearance can be forlorn and their capacity suggest thirst. However, it is difficult to construe the next two examples in any other way than as metaphorical. A contrite bucket must be some kind of figurative bucket. A human bucket is probably a person, not even akin to a bucket in appearance but merely enjoying some property of buckets like being a capacious receptacle for liquid.

Such examples demonstrate how minute semantic accretions of animacy in an adjective can eventually, when it is juxtaposed with a concrete noun, set up a semantic conflict and disrupt expectations of government.

It is not clear that verbs should invariably be recognised as heads either. Dependency grammar would designate the verb 'shine' as the head in the following example,

girls shine in single-sex education

as if its meaning were ontologically fixed and the other components merely provided a further description of the

process of shining.

This view of modification was a commonplace. We can compare Jespersen's categorial interpretation of the parts of speech where nouns were categories of the first degree, verbs and adjectives of the second and adverbs the third. Each category is modified by a category of higher degree, for example, nouns by verbs and so on (Lyons 1968).

This does not appear to be invariably true. Semantic coercion or modification is not merely a function of syntactic category. Thus some other principle of disambiguation of semantic anomalies is required.

5.7 Inadequacy of a quasi-physical model.

It has been suggested that postulating a quasi-physical realm can account for the resolution of semantic anomalies. This, however, would be to claim that in,

Father Blaney's thoughts flowed to Knock

the thoughts had some physical properties. This does not seem to be true. There is no literal liquefaction of the thoughts. You can't dip your toe in them and draw it out wet or pour the thoughts over a dry-clean only suit and ruin it. Nor can thoughts move since they have no location. One can imagine them flowing but that's not the same thing.

It is certainly true that the choice of a particular kind of

metaphorical realm, in this case a watery one, imposes some stylistic constraints upon the subsequent choice of metaphors but the point is that they will still be metaphors: they are not intended to have a literal application to the subject or change it ontologically in any way. This fact is obvious to human beings but we need a principled method of determining, first of all, when a metaphor is present, and, secondly, how its semantics is to be resolved.

Chapter 6.

----- A semantics of prediction and coercion: prediction. -----

One of the aims of this research is to devise a method of predicting the semantic class of an unknown word in a sentence from the class of a known word or linguistic structure of that sentence. We have seen how various mechanisms open to us, such as selectional restrictions, meaning postulates, feature unification and syntactic government fail to provide a means of predicting or resolving meaning.

We assume that there exists a large corpus of non-specific linguistic material that one would find in any subject. In other words, not all words are technical. It is suggested that the domain-specific words are usually nouns, but also a percentage of the verbs. There are, however, a great many other words, including some generic nouns and verbs but also most adjectives, prepositions, adverbs and so on, that turn up in all subjects but which convey information and from which inferences can be drawn.

As an exercise the reader might try replacing all the uncommon nouns in a passage of text with nonce words or variables. The resulting text is surprisingly informative. This is why one is able to have the semblance of a conversation with someone even though most of the technical terms he uses are unknown. Here is an example.

*s can be used for cutting or trimming *s as well as for other duties although a pair of * *s are often handy. Both must have * *s. A large ordinary * and a small *'s * with an * * are also necessary. A * * such as a * * is useful for paring off * * from *s but on smaller * this can be done with a pair of *s.

Winograd (Schank and Colby 1973) points out that elucidation of unknown words is partly achieved by syntax:

..... people are able to interpret sentences syntactically even when they do not know the 'meaning' of the individual words. Most of our vocabulary beyond a certain age is learned by hearing sentences in which unfamiliar words appear in syntactically well-defined positions.

Thus, in the above example, the first two unknowns occur in the syntactic position of noun phrases and the presence of an 's' suffix and the absence of any determiner in either case suggests a plural. In line 2 the phrase 'a pair of * *s' likewise suggests a complex noun phrase or a noun preceded by an adjective. In line 3 'a small *'s *' suggests a possessive noun phrase. In line 5 the phrase 'smaller *' suggests a mass noun because of the absence of a plural ending.

This is not all we can infer, however. As well as a knowledge of syntax we bring to bear semantics in elucidating word meaning.

Thus, in line 1, we assume that the first unknown refers to some variant of scissors and the second some physical count noun. In line 2 we are told that 'a pair of * *s' are a common alternative to the scissory things in line 1. Both must have '* *s'. From this we may infer that this is some necessary

component of the scissors, the most obvious being some kind of blade. In the next sentence two more unknowns are required to continue with the same cutting and trimming operation or one associated with it. Thus they are probably some kind of tool, the latter being preceded by a possessive adjective suggesting the typical user of the tool. In line 4 'a * * is useful for paring off *' suggests some kind of knife and some kind of integument. Thus elucidation depends on syntactic, morphological, lexical (things that are cut are usually physical objects) and world (scissors have blades) knowledge.

Here is the complete text, taken from an electricians' manual.

PLIERS can be used for cutting or trimming WIRES as well as for other duties, although a pair of SIDE-CUTTERS are often handy. Both must have INSULATED HANDLES. A large ordinary SCREWDRIVER and a small ELECTRICIAN'S SCREWDRIVER with an INSULATED SHAFT are also necessary. A CRAFT KNIFE such as a STANLEY KNIFE is useful for paring off PVC SLEEVING from CABLES but on smaller WIRE this can be done with a pair of WIRE-STRIPPERS.

It is suggested that a computer program that could make this kind of inference would be able not only to function as a knowledge elicitation device but would also have theoretical linguistic value especially if it could be shown that a dialogue can be coherent, though possibly misleading, even though a large part of the nouns and verbs are not understood.

The sort of information that can be derived from these everyday words can be causal, hierarchical, equivalent, meronymous, functional, set-theoretical, logically-sequential, temporal, spatial, thesaural, inferential and quantificational.

This function of the program has been partially addressed by others, for instance, in Wilks' (Wilks 1972) computable semantic derivations system, the sense of 'sport' can be disambiguated in

Grogan is a good sport
shinty is a good sport

Thus, information about unknown words, or about ambiguous senses of known words, can be inferred from the linguistic context.

A word of a known class can be used to predict the class of the unknown word with which it combines syntactically. In actual fact, the semantic class of each predicate P in a logical form, may constrain or be constrained by the semantic class of any predicate Q that shares an argument X with P. However, for the purposes of predicting the class of an unknown word, we consider only the semantic class of the word with which it syntactically combines. For example, in the sentence

gentlemen prefer blondes

represented by the Prolog clause

```
prefer(X,Y) :- gentlemen(X), blondes(Y)
```

the predicate 'prefer' shares an argument with the predicate 'gentlemen' and the predicate 'blondes' and thus its meaning can be semantically constrained by them and vice versa. The only two predicates that do not share an argument are

'gentlemen' and 'blondes'. However, for the purposes of predicting the semantic class of the word 'prefer' we use only the word with which it syntactically combines in our phrase structure rules (verb-phrase --> verb noun-phrase) namely 'blondes'.

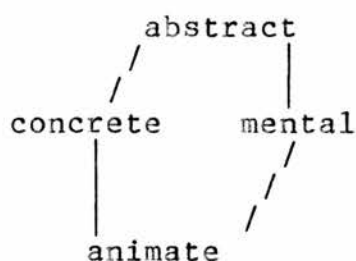
The following table gives, for each semantic class of each syntactic structure, the predicted semantic class for the word it syntactically combines with.

C stands for concrete, M for mental, A for animate, B for aBstract and F for figurative, according to the classification system described above for the classification of known words.

The arrow stands for 'predicts', thus, in the adj-noun column, C --> C or A means 'where a concrete adjective combines with an unknown noun to give a noun phrase, that noun is predicted to be of the class concrete or animate'. The predicted classes are as follows.

adj noun	verb noun2	vp noun1	s	s-adverb
A -->A	A --> A or C	A --> A	A --> ?	
C -->C or A	C --> C or A	C --> C or A	C --> C or B	
M -->M or A	M --> ?	M --> M or A	M --> M or B	
B -->?	B --> ?	B --> ?	B --> B	
C or B <-- C	? <-- C	B or C <-- C	F --> ?	
M or B <-- M	M or B <-- M	B or M <-- M	A or C <-- C	
B <-- B	M or B <-- B	B <-- B	A or M <-- M	
? <-- F	? <-- F	? <-- F	? <-- B	
? <-- A	? <-- A	? <-- A	A <-- A	

It may be observed that these predictions follow a general principle. We recall that the ontological hierarchy is as follows.



It should be pointed out that 'can be class X' here should be read as 'some dimension of it is class X without coercion into a different sense'. The difference between a new dimension and a new sense can best be illustrated by examples. For instance, in the following sentences

the watchdog gave a yip
 the watchdog dreamed of liver and lights

the word 'watchdog' has the same sense and may well refer to the same animate object which is nevertheless engaging in a physical activity in its physical dimension and a mental activity in its mental one. On the other hand, in

the National Front is the watchdog of Britain's liberties

the word 'watchdog' is used in a quite different (albeit related) abstract sense, in an identity statement with another abstract object, the National Front. In the following prediction principles we are concerned only with the most basic sense of a word not any secondary or metaphorical one. 'Below' and 'above' refer to the hierarchy represented by the above diagram.

The Principles of Prediction.

The prediction principles are as follows. (Examples are given below.)

A noun's class can be any class below or including the class of the adjective with which it syntactically combines.

A subject noun's class can be any class below or including the class of the verb phrase with which it combines.

A sentence's class can be any class below or including the class of the sentential adverb with which it combines.

An object noun's class can be any class below or including the class of the verb phrase with which it combines (where the hierarchy is conflated into two classes, the superordinate abstract + mental and the subordinate animate + concrete).

A verb's class can be any class below or including the class of the verbal adverb with which it combines (where the hierarchy is conflated into two classes, the superordinate 'abstract + mental' and the subordinate 'animate + concrete').

An adjective's class can be any class above or including the class of the noun with which it combines.

A verb phrase's class can be any class above or including the class of the subject noun phrase with which it combines.

A sentential adverb can be any class above or including the class of the sentence with which it combines.

A verb phrase's class can be any class above or including the class of the object noun phrase with which it combines (where the hierarchy is conflated into two classes, the superordinate 'abstract + mental' and the subordinate 'animate + concrete').

A verbal adverb's class can be any class above or including the class of the verb with which it combines (where the hierarchy is conflated into two classes, the superordinate 'abstract + mental' and the subordinate 'animate + concrete').

The above prediction principles merely lay down descriptive rules for the way the four primary semantic classes behave with respect to one another. They merely claim that, say, class X

and class Y are potentially compatible in, say, an adjective noun combination. No claim is being made that adherence to these rules would eliminate every anomalous word-marriage.

For one thing, fine-grained anomalies can occur within the boundaries of one semantic class ('buxom policeman', 'grill the toast'). For another, two words taken from two semantic classes that the rules predict to be compatible may nevertheless not be so. For instance, we predict that an adjective can come from any class above or including the class of the noun with which it combines. For instance, it seems sensible to predict that concrete adjectives can be applied to animate nouns with impunity. However, 'wet Betty' is fine while 'cast-iron Betty' is probably anomalous. This does not provide sufficient grounds for abandoning the prediction principle but suggests that an enhancement of the theory might sub-divide the class concrete in a useful way.

We can test the predictions made by this table against the sample lexicon incorporated in the small demonstration program in Appendix 2.

	adj	noun	verb	adverb
animate	forlorn	man	avoid	loquaciously
concrete	metal	bucket	output	mechanically
mental	contrite	mind	despise	angrily
abstract	French	theory	vitiate	mathematically

We can expand the first entry in the prediction table as follows. Given an animate adjective, such as 'forlorn' or 'cross-eyed', we can predict that the noun that it combines

with to make a noun phrase, if unknown, will probably be from the class animate, for instance 'man', 'gypsy' or 'ocelot'.

We can make some generalisations. An abstract adjective is promiscuous, as one would expect from its non-intersective nature, and will combine with any category of noun and thus cannot predict any, for instance,

French man
French bucket
French mind
French theory.

Compare also other abstract adjectives.

Didier's X
the controversial X
a different X
a Cartesian X

An abstract adverb is promiscuous for the same reason. It will combine with any sentence or verb and thus cannot predict any one class of sentence or verb.

the woman avoided the man yesterday
the machine output the bucket yesterday
the mind despised the memory yesterday
the argument vitiated the theory yesterday

A mental verb is also promiscuous: thus it does not predict any particular class of object noun. This is because one can address one's mind to anything whether concrete or abstract.

Mental verbs are compatible with all object nouns including those higher in the hierarchy.

Father Blaney liked chocolate
Father Blaney liked his mum
Father Blaney liked daydreaming
Father Blaney liked lycanthropy

What is being claimed here is that a verb phrase created by combining a mental verb and any class of object noun will be classified as mental. It may seem tendentious to suggest that, in these examples, the verb 'like' is not semantically coerced by the noun that follows it, but what is important is that there is not sufficient coercion, even from the abstract noun 'lycanthropy' to change the ontology of the verb 'like' which still refers to a mental state. Even if we paraphrase 'liked chocolate' as 'liked eating chocolate' the phrase still refers to mental activity: not just eating but liking to eat! Contrast these examples with the following ones.

Father Blaney exposed the camera film
Father Blaney exposed his person
Father Blaney exposed his innermost thoughts
Father Blaney exposed lycanthropy

It is clear here that the ontological status of the verb 'exposed' is undergoing coercion from a trivial physical action to a complex abstract one.

Incidentally, the coercion in the above sets of examples is in accordance with what would be predicted by the selectional restrictions or selectional preferences imposed by the respective verbs.

The verb 'like' prefers an animate subject but does not prescribe an object. Thus any object is absorbed into the

mental verb phrase established by the verb 'like'.

The verb 'expose', on the other hand, prefers a concrete subject and a concrete object. Thus any sentence that violates this selectional preference needs a semantic principle to resolve it. It is just such a principle that we seek to identify here.

An animate sentence will combine with any class of adverb. As we have seen, this is because it is compatible with both the class concrete and the class mental and also the class abstract since everything has an abstract dimension of functionality or significance to human beings.

Modeste coughed noisily
Modeste coughed hoarsely
Modeste coughed apologetically
Modeste coughed unnecessarily

An animate noun will combine with any class of adjective for the same reason, that is, it is compatible with concrete, and mental and also abstract since it has an abstract dimension.

wet man
forlorn man
contrite man
French man

Since figurative is a combination of the concrete and either mental or animate, a figurative sentence, like an animate one, will also combine with any class of adverb.

the dustbin coughed noisily
the dustbin coughed hoarsely

the dustbin coughed apologetically
the dustbin coughed yesterday

Concrete subject nouns, verbs and verb phrases predict
concrete verb phrases, object nouns and subject nouns
respectively.

the bucket rattled
... output the paper
the machine output the paper

Animate verb phrases and adverbs predict animate subject nouns
and sentences respectively.

Hippolyte laughed
Hippolyte laughed animatedly

Mental subject nouns predict mental verb phrases.

his mind despised the self-deception

Abstract subject nouns, nouns, verbs, verb phrases and
sentences predict abstract verb phrases, adjectives, object
nouns, subject nouns and adverbs respectively.

the evidence proved the theory
the French theory
vitiating the argument
the error vitiated the argument
the error vitiated the argument completely

Figurative subject nouns and object nouns, since figurative is
a combination of concrete and animate or mental, predict
concrete, animate or mental verb phrases and verbs
respectively.

the happy dustbin rattled
the happy dustbin laughed
the happy dustbin repented

electrocuted the happy dustbin
kicked the happy dustbin
liked the happy dustbin

Concrete object nouns predict concrete or animate verbs. They also predict mental verbs since a mental verb can address itself to any object.

...output the paper
...tore the paper
...approved of the paper

Animate nouns can combine with concrete, animate or mental adjectives and verb phrases as we would expect.

the wet man
the forlorn man
the contrite man

the man fell
the man trembled
the man thought

Mental adjectives, verb phrases and adverbs predict mental or animate nouns, subject nouns and sentences respectively.

happy thought
happy man

Modeste recalled the mental-image
his memory recalled the mental-image

his memory recalled the mental-image angrily
Modeste kicked the puffball angrily

Animate adjectives predict animate and mental nouns and verb phrases.

Animate object nouns predict anything.

happy man
happy memory

hit the man
liked the man
avoided the man
vibrated the man

Concrete nouns and sentences predict concrete adjectives and adverbs respectively. They also predict abstract ones since abstract adjectives and adverbs are promiscuous.

metal bucket
controversial bucket

the bucket fell noisily
the bucket fell inevitably

Mental nouns and sentences predict mental or abstract adjectives and adverbs respectively.

happy thought
controversial thought

his mind pondered the idea relentlessly
his mind pondered the idea yesterday

Abstract object nouns predict mental or abstract verbs.

liked the hypothesis
justified the hypothesis

Concrete adjectives and adverbs predict concrete or animate nouns and sentences respectively.

wet bucket
wet man

the bucket fell noisily
the man sang noisily

Animate verbs predict concrete or animate object nouns.

hit the ball
hit the man

Two points should be made in conclusion. One is that fine grained anomalies are not accounted for here. Thus a concrete adjective predicts a concrete or animate noun. This is obviously true for 'wet' but not true for 'metallic' since 'metallic man' although not meaningless is hardly a phrase that one would predict.

The second point is that, by restricting ourselves to making predictions from words that syntactically combine with each other, some inferring power is lost. For example, in the sentence

the theory contains X

the semantic class of the unknown word X is predicted from the verb 'contains'. This is a concrete verb and will predict a concrete or animate object noun. It is far more likely that X will denote an abstract noun as we can infer from the noun 'theory'.

Chapter 7.

A semantics of prediction and coercion: coercion.

7.1 Coercion.

Another aim of this research is to determine the semantic class of a linguistic structure from the semantic classes of its constituent words. This aim is non-trivial in that there are presumed to be no selectional restrictions on the classes of words that can combine in a structure, owing to exemplasy or the unifying power of the imagination to combine virtually any concepts. Selectional preferences may help us predict the meaning of unknown words but violation of selectional preferences does not result in nonsense.

It can be seen that this aim (determining the semantic class of a linguistic structure from the semantic classes of its constituent words) is intimately bound up with our previous task of discovering a principled method of predicting the meaning of unknown words, since prediction is dependent on the semantic class of adjacent words or structures and thus all structures must be classified semantically.

Our rejection of selectional restrictions does not mean that we cannot predict the probable class of an unknown word from its neighbours but merely that the resulting linguistic structure will not be meaningless just because the class of the unknown word turns out to be different from what we have

predicted. Selectional restrictions have been replaced by selectional preferences.

It is claimed that there is a hierarchy of classes such that where two words combine in a structure and those words have incompatible semantic classifications then the class of the resulting structure will be the class of the two that is higher in the semantic hierarchy or will be a special class outside the hierarchy, namely figurative.

Two words are deemed to be semantically incompatible if they violate the prediction principles outlined above.

When two words combine that are semantically compatible, that is, in accordance with the prediction principles, the semantic class of the resulting structure will be that of the syntactic head of that structure.

Syntax cannot always provide the semantic class of a linguistic structure however. As we have seen, the following examples demonstrate how minute semantic accretions of animacy in an adjective can eventually, when it is juxtaposed with a concrete noun, set up a semantic conflict that compromises the semantic class of the syntactic head.

immobile bucket
metal bucket
cold bucket
jogging bucket
smiling bucket
talkative bucket

There is a strong tradition in linguistics to treat nouns and

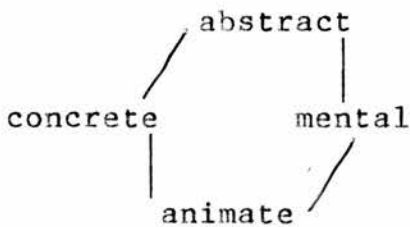
adjectives as heads and adjuncts respectively, for all purposes. This would predict that, regardless of semantic class, the noun would determine the ontology of the noun phrase. There seems little doubt that this is untrue in the last example ('talkative bucket'). There is obviously some kind of metaphor involved, (even if only an evanescent one) or even a full-scale figurative scene yet to be unravelled. The argument is less conclusive in the case of 'jogging bucket' where the jogging may be the jogging of an autonomous agent (the android bucket) or alternatively the result of an external force like the man carrying it.

So, resolution of anomalies (that is, structures that violate the prediction principle) is achieved by reference to a semantic hierarchy. It should be noted that this is not the ontological hierarchy that is discussed above but a hierarchy of coercion.

The hierarchy is, from lowest to highest

concrete < animate < mental < abstract

The ontological hierarchy that was discussed earlier can be thought of as a hyponymy lattice. Here it is again to refresh the memory.



Thus, an animate thing is a kind of concrete thing. Mental objects are a kind of abstract object and so on. All concrete things have an abstract dimension (their functionality) but not vice versa so the lattice could not have been the other way up.

Now, this hierarchy, although it represents an ontological hyponymy relation cannot be used to resolve semantic anomalies for the simple reason that it does not constitute a linear relation of dominance. In other words, it is not possible to say of every pair of elements which of the two is subordinate to the other.

What we want to know is which of two semantically conflicting elements in a linguistic structure should take precedence and coerce the other.

For this purpose we need what Cruse calls a linear relation of dominance or a semantic coercion hierarchy. The one we will use is as above:

concrete < animate < mental < abstract

If one looks carefully at the phrase

thoughts flowed to Knock

(for instance, in the sentence 'Father Blaney's thoughts flowed to Knock'), one sees that the two words 'thoughts' and 'flowed' are semantically incompatible according to our prediction principle. However, there does not seem to be an equal coercion or negotiation between the two words 'thoughts' and 'flowed'. They do not both mutate. There is no liquid trajectory across the Irish Sea. The meaning of the word 'thoughts' remains constant; 'flowed', on the other hand, is coerced such that the resulting phrase has an abstract and metaphorical reading.

It may be argued however that a concrete dimension has been imposed by the word 'flowed' and that this can be demonstrated by the stylistic constraints placed on subsequent text. For example, it has been pointed out to me by Ronnie Cann, that a pleasing conclusion to the sentence might be

Father Blaney's thoughts flowed to Knock and eddied around the shrine

while the following

Father Blaney's thoughts flowed to Knock and exploded over the shrine

would be infelicitous. It does not seem to me however that the presence of an extended metaphor of this kind, felicitous or otherwise, in any way compromises the ontological nature of a thought in this sentence. This is why we would describe the above sentences as 'metaphorical' rather than as sentences conveying a literal truth.

Of course no account has been offered of why so-called mixed metaphors are stylistically unsatisfactory but this is beyond the scope of this thesis which does not seek to be prescriptive but rather to disambiguate. Thus, 'thoughts flowed and exploded' would be classified as an abstract construction. There is a fine-grained anomaly in the phrase 'flowed and exploded' which we would need an enhanced semantic principle to resolve.

Suppose, first of all, for simplicity, that we roughly classify all words into two classes, viz, abstract and concrete. If the two component words or phrases of a larger semantic structure conflict because one is abstract in meaning and the other concrete, the resulting syntactic structure will be abstract, for example, a concrete verb and abstract object noun

(Father Blaney) swallowed the lie

yield an abstract verb phrase. Thus, Father Blaney does not engage in a physical act of swallowing but merely a metaphorical one.

Likewise an abstract verb and concrete object noun, for instance,

(Father Blaney's condition) justified the bucket

yield an abstract verb phrase, the appropriate sense of the verb phrase being something like 'justified the presence of the bucket' rather than some concrete reading like 'aligned the

bucket'.

A concrete verb phrase and abstract subject noun, for example,
the thought struck Vernon

yield an abstract sentence, since the sentence, although
apparently about striking, does not describe a state of affairs
apprehensible by the senses and thus does not have a concrete
sense. Likewise, an abstract verb phrase and concrete subject
noun, for instance,

the bicycle-lamp pleased Vera

also yield an abstract sentence rather than a concrete one
since the situation described is not apprehensible by the
senses.

A concrete adjective (or adjectival phrase) and abstract noun,
such as

watertight argument
green thoughts in a green shade
heavy criticism

yield an abstract noun phrase. Thus, arguments have no literal
seaworthiness, nor do thoughts have colour (at least no colour
that is apprehensible by the senses), nor criticism avoir du
poids.

A concrete adverb and abstract verb phrase

(Father Blaney) thought warmly of (the Taylor's 55)

yield an abstract verb phrase since thoughts are not literally warm but only metaphorically so.

The coercive trend can be seen developing in the following sequence.

Jim tore the paper apart
Jim tore the newspaper apart
Jim tore the book apart
Jim tore the thesis apart
Jim tore the theory apart
Jim tore the ideology apart

The watershed in these context-independent sentences seems to be when 'thesis' is reached since it is a word that is used chiefly in its abstract sense although it has a technical concrete usage, especially in universities, that allows a concrete reading for the whole sentence. It is hard to interpret the final example in any other way than a metaphorical one. Of course, given appropriate contexts, either reading would be applicable to all these examples.

As we saw above, there can be semantic anomalies at all levels of language. Not all anomalies are at the coarse-grained level of basic ontological types (consider 'Leroy grilled the toast') and a more detailed analysis of these than the one offered here is needed.

A finer grained classification of words than the classical abstract/concrete dichotomy can be given however. This has been achieved by the creation of two further basic classes, namely animate and mental, and a derivative one, namely figurative.

The principle of hierarchical coercion also applies to these two basic classes.

A full table of semantic predictions and coercions can be found in Appendix 1. There follow a verbal description and examples of the basic principle of coercion.

The Principle of Coercion.

In cases of anomaly, that is where the above prediction principles are flouted, semantic coercion is exerted by words of a higher semantic category over words of a lower one, where the hierarchy of categories, from lowest to highest, is, as we have seen,

concrete animate mental abstract

It should be remembered that, although the semantics of every word in a sentence is potentially influenced by the semantics of every other, we restrict ourselves here to influences between words that combine syntactically, according to our phrase structure rules, to form a larger linguistic unit. For instance, an adjective combines with a noun to make a noun phrase.

A concrete adjective is compatible with concrete and animate nouns but is coerced by all higher categories of the noun with which it combines to form a noun phrase. Thus a concrete adjective and an animate noun will take the semantic class of

the semantic head, namely animate, for instance,

black man
wooden traffic warden
metal merchant (e.g. scrap metal merchant)

(For exceptions to this rule pertaining to models, see Section 7.4.)

A concrete adjective and a mental noun however, for instance,

a black humour
(e.g. Hippolyte has been in a black humour all day)
green thoughts

yield a mental noun phrase, and a concrete adjective and an abstract noun, for instance,

black humour (i.e. black comedy)
cast-iron theory
the empire, in its pinafore
a rotten theory

yield an abstract noun phrase in accordance with the semantic hierarchy.

A mental adjective coerces concrete nouns, is coerced by abstract nouns and is compatible with animate nouns. For instance, a mental adjective and an animate noun yield an animate noun phrase:

contrite man

A mental adjective and a concrete noun yield a mental noun phrase:

mental gymnastics
the spiritual exercises (of St. Ignatius Loyola)

or a figurative noun phrase:

contrite bucket
(e.g. the contrite bucket mumbled its apologies)

A mental adjective and an abstract noun yield an abstract noun phrase, for instance,

contrite theory

suggests a theory espoused by the contrite. It does not suggest that the theory has been ontologically coerced into some kind of intentional being.

The coercion principle is semantic not syntactic thus, in a semantically anomalous noun phrase, nouns coerce adjectives in the same way as adjectives coerce nouns, that is, in accordance with the semantic hierarchy, and we can deduce that headedness is not significant.

An animate noun is compatible with concrete, abstract, animate and mental adjectives. Thus, all the following yield animate noun phrases:

a wet man
a furtive man
a contrite man
a traditional man

Compare

a mathematical giant

which even though it exhibits a high degree of semantic negotiation between the words does not compromise the classification of 'giant' as animate.

A concrete noun combines successfully with concrete and abstract adjectives. A concrete noun is coerced by animate and mental adjectives into yielding a figurative noun phrase. Thus

wet bucket
traditional bucket

yield concrete noun phrases, but

furtive bucket
contrite bucket

yield figurative noun phrases.

A mental noun coerces all adjectives in the categories below it but is compatible with mental and abstract adjectives, for example, all the following yield a mental noun phrase:

green mind
forlorn mind
contrite mind
traditional mind

An abstract noun coerces all the adjectives in the categories below it. All the following examples yield an abstract noun phrase:

metal theory
forlorn theory
contrite theory

A truly concrete transitive verb is a rare category comprising

just a few neologisms like 'output' and 'autoprint', although intransitive concrete verbs are, for obvious reasons, far more common, for example 'fall' and 'smell'. The latter do not concern us here as we are considering the relation between verbs and object nouns.

It may be argued that, of course, there are many concrete transitive verbs such as 'hit', 'strike', 'touch', 'cut' and so on. These actions are clearly apprehensible by the senses and physical objects can engage in them ('the lightning struck the fowling-piece and the bullet hit the shooting-brake').

However, these verbs usually involve an animate agent and more often than not the instrument of the action is left out all together ('Hippolyte cut the cake'). Thus, such verbs are not good prototypical examples of the class concrete.

A concrete transitive verb is compatible with concrete and animate object nouns but is coerced by mental and abstract object nouns. The following yield concrete verb phrases:

output a bottle
output a man

However a concrete verb and a mental object noun yield a mental verb phrase:

output hostility (e.g. generated an aura of being hostile)

while a concrete verb and an abstract object noun yield an abstract verb phrase:

output controversy (e.g. was the cause of controversy)

An animate verb is compatible with concrete or animate object nouns; any object noun in a higher category (including figurative because that contains one mental element) coerce it. For example, the following yield animate verb phrases:

avoided the bucket
avoided the horse

However, an animate verb and a figurative object noun yield a figurative verb phrase, for instance:

avoided the apologetic bucket

An animate verb and a mental object noun yield a mental verb phrase:

rummage through the mind

while an animate verb and an abstract object noun yield an abstract verb phrase:

smash the theory

A mental verb is compatible with any object noun since the mind can address itself to anything: nothing except the logically impossible is unthinkable (pace Blackburn's claim that the prurient mind finds it impossible to think of an unoccupied bed). Thus, all the following yield mental verb phrases.

loved the dustbin
loved the chiropodist
loved the daydream
loved the propaganda

An abstract verb is compatible with every class of object noun, because it appertains to some abstract dimension of that object noun, for example:

vitiating the bucket (e.g. its existence)
vitiating the consultant (e.g. his diagnosis)
vitiating the thought (e.g. its truth)
vitiating the theory (e.g. its robustness)

A concrete verb phrase containing a transitive verb is, as we have seen, a rare category exemplified only in, for example, 'output the document' and 'autoloading the disc'. It is compatible with concrete and animate subject noun phrases:

the machine output the document
the man output the document
(e.g. caused the machine to output the document)

yield concrete sentences.

The paucity of concrete transitive verbs make a proper analysis difficult. The concrete transitive verb phrase 'output the document' in conjunction with a mental subject noun should, according to our theory, produce a mental sentence. However, verbs like 'autoload' and 'output' are neologisms that have not yet acquired a metaphorical currency. Their meaning is fixed and they resist any coercion at all. The sentence

dogged determination output that document
(e.g. made the man make the machine output that document)

should yield a mental sentence. However, the reader will notice that in such anomalous sentences as this the only sane reading is a highly elliptical one and it is odd to classify the whole sentence as mental.

If it seems far-fetched to classify this sentence at all (and it does since elliptical sentences can be as disjointed in meaning as conjoined sentences) some examples using intransitive verbs (for example, 'stink', 'fall') may be more compelling. In the following, the concrete verb is compatible with the concrete and animate subject nouns but ^{is} coerced ^{by} the mental and abstract ones.

your fridge stinks
your aunt stinks
your mind stinks
your monograph stinks

the rain fell
Hippolyte fell
his spirits fell
house prices fell

An animate verb phrase in combination with a concrete subject noun yields a figurative sentence, for example

the rain avoided the Long Mynd

while an animate verb phrase and an animate noun, for instance

the janitor accosted the man

are compatible and yield an animate sentence. However, higher category subject noun phrases coerce an animate verb phrase,

for example:

Hippolyte's conscience pricked him

yields a mental sentence (since Hippolyte is not physically pricked in a way apprehensible by the senses), and

the evidence undermined Hippolyte

yields an abstract sentence (since Hippolyte is not literally standing on top of, say, a coal field).

A mental verb phrase coerces a concrete subject noun phrase into its figurative dimension but is compatible with animate and mental subject noun phrases. It is coerced by an abstract noun phrase, for example:

the bucket knew the ...yields a figurative sentence
the man knew the ... yields a mental sentence
his conscience regretted the ... yields a mental sentence
the verdict acknowledged that.....yields an abstract sentence

An abstract verb phrase is compatible with every category of subject noun with which it combines, for example:

the bucket vitiated ... (e.g. its existence vitiated...)
the man vitiated ... (e.g. his presence vitiated...)
the memory justified ... (e.g. its occurrence justified...)
the ubiquity of the bastinado justified ...

A concrete adverb is compatible with concrete and animate sentences, for example:

the machine throbbed mechanically
the man jogged mechanically

but is coerced by sentences of a higher category, for example:

Hippolyte thought mechanically

yields a mental sentence;

the conclusion proceeds from the premises mechanically

yields an abstract sentence.

An animate adverb coerces a concrete sentence into the figurative dimension, for instance

the bucket overflowed dejectedly

but is coerced by higher categories; for example:

Didier thought sweatily

yields a mental sentence

Hercule vitiated the argument sweatily

yields an abstract sentence.

Incidentally, having established the semantic principle, it is possible to apply it to linguistic structures in order to determine the classification of their components. For example, suppose we were uncertain as to the semantic classification of the two words 'crowd' and 'community'. In the following phrases, the adjective 'wet' appears to be coerced in the second phrase but not the first.

wet crowd
wet community

This suggests that 'crowd' must be animate or concrete since it is compatible with the concrete adjective 'wet'. However 'wet' is coerced by 'community' into a non-apprehensible sense which suggests that 'community' is either mental or abstract. The same technique could be used to establish the class of other words.

A few words should be said in conclusion about verbal adverbs. We have considered so far only sentential adverbs or adverbial phrases like 'yesterday', 'hastily' and 'without his umbrella'. However, there are of course verbal ones like 'up' and 'about'. The reason they are dealt with only briefly here is that they appear to be almost entirely restricted to the semantic class concrete, for example, 'up', 'in', 'through' and so on. There seems a strong case as well for classifying apparently temporal adverbs, such as 'before' and 'after' as concrete since we apply them so readily to concrete situations without any of the ratiocination typical of abstract thought.

We can analyse the following examples along the usual lines. In the phrase 'in a quandary' the preposition 'in' is spatial and therefore concrete, while 'quandary' is abstract. The principle predicts that the whole phrase is therefore abstract.

In the following sentence,

see Birkin about sending more ericacious potting compost

'see' and 'about' would be classified as animate and concrete respectively, and thus we would expect that the phrasal verb 'to see about' would be animate since its components are compatible.

The phrasal verb 'to see about' has various meanings: 'to do whatever is to be done about', 'to attend to' and 'to consider' (Chambers 1983). The first two of these definitions would be assigned the semantic class animate and the third mental. Thus, the lower (in the semantic hierarchy) semantic classification of the phrase, which is the one we always default to, is the same as that predicted by the semantic principle, namely animate.

It may be argued that we are making very heavy weather here of the simple fact that verbs like 'see' and 'look' are ambiguous. On the contrary, it seems rather that they are polysemous, (Crystal (Crystal 1985) says 'a large proportion of a language's vocabulary is polysemic') and moreover that so many words are polysemous (for example, 'expose the film', 'expose the fraud') that we need a principled way of establishing which of a word's many senses is being used on a particular occasion and what aspects of its linguistic context are determining its sense.

Some phrasal verbs cannot be dismantled in this way but are incontrovertibly non-compositional, for instance, in
ring up Birkin!

there is no upwards motion in the matter, although one can imagine the evolution of this phrasal verb from other more compositional ones such as

rouse up Birkin from his pallet!

The idiom can nevertheless be analysed in the same way that 'see X about' was analysed above. It may be that, while meanings are not always compositional, yet semantic classes are.

7.2 Overriding.

Although the Principles of Prediction and the Principle of Coercion (stated in Chapters 6 and 7.1 respectively) are broadly true, it must be said that computed categories can be overridden by an accumulation of later evidence.

Underspecification of phrases is not uncommon (I once saw a box with the words 'The Improver' written on it). Sometimes even whole sentences are ambiguous. This view has the support of the modern day empiricist Quine who, in 'Word and Object' (Quine 1960), put forward the thesis of the 'indeterminacy of radical translation' or the view that a sentence can always properly be regarded as meaning a multitude of different things.

Of course all pragmatic theories of meaning that regard context of utterance as an indispensable component of meaning would support this view. Such a position seems to me to be dodging the question of the ineradicable quiddity of each word and its influence on others regardless of context.

Anyway, indeterminacy of translation apart, in this work the semantics is deemed to be compositional and monotonic despite the possibility of later semantic counter-evidence. Thus, 'the thirsty bucket' is deemed to be figurative. However, one needs to look at the rest of the sentence to determine whether this is merely metaphorical usage or part of a full scale figurative scenario, for example, respectively:

the thirsty bucket overflowed with water
the thirsty bucket winked at the dour pump.

For the same reason, it is slightly tendentious to claim, as we do above, that a sentential adverb can coerce the semantics of a whole sentence. Thus,

the floor creaked accusingly

while open to figurative interpretation, contains enough accumulated concrete evidence to render the adverb merely an evanescent metaphor.

7.3 Negotiation. -----

As mentioned above, feature unification semantics cannot resolve conflicts such as

Father Blaney swallowed the lie

since the verb and object noun being concrete and abstract (or +physical and -physical) would not unify. Some people may object that the meaning of 'swallow' here is clearly a secondary meaning and moreover the noun 'lie' would disambiguate the verb 'swallow' and feature unification could go ahead. This seems untrue. 'Swallow' here, although apparently only remotely connected with the ingestion of food, is nevertheless etymologically the same. Physical terms are often used in connection with mental attitudes, for instance,

Grundy accepted the spoonful/ the idea
Grundy rejected the mouthful/ the offer
Grundy took in the news/ the water
Grundy took on board the porridge/ the truth
Grundy swallowed the jelly/ the lie
Grundy regurgitated the story/ the junket

Of course it is possible for one's lexicon to enumerate all the different senses of these words separately but this would be to deny that there is such a device as metaphor but merely many unrelated senses for one orthographical form. One need only open a dictionary to see how many senses words have.

It could be argued that every concrete term had these two dimensions, namely, physicality and some kind of functionality. This would be in accordance with the views of Descartes and the rationalists who thought we must project constructions onto reality in order to make sense of chaos. Thus, we can see the physical continuum of reality and also possibly chairs qua physical objects but must project onto reality its functional or abstract properties.

We may fear that the existence of multiple senses of words prevents semantics being compositional. However, because the orientation of a jigsaw piece is not determined when you put it down on the table that does not mean that the jigsaw is not compositional. Some pieces (say, pieces of sky), like some words, have many different orientations (for example, a rebarbative hedge/ traffic-warden/ statute). Others, like a jigsaw piece with a face on, are less troublesome. The face will almost certainly go chin downwards in the picture.

Likewise 'molewrench' is unlikely to be promiscuous in its usage.

It has to be said however that, while a general principle of semantic coercion can be sustained, there appears to be some mutual negotiation of meaning between words that combine in a sentence even where one is clearly of a higher category than the other.

This, of course, is not always true: a 'watertight argument' is not compromised by 'watertight' in its abstract ontological status at all. It is 'watertight' that undergoes a dramatic metamorphosis. It does seem however that some words change their senses subtly whilst behaving in accordance with the semantic principle. For example, mental verbs, according to the semantic principle, are compatible with any object noun. However, 'know' varies in sense in the following examples according to the noun with which it combines, whilst preserving its ontological class.

Antrobus knew roly-poly pudding
Antrobus knew suffering
Antrobus knew Murdo
Antrobus knew metallurgy
Antrobus knew Murdo's address
Antrobus knew Murdo was lying

Such semantic shifts are too finely calibrated for detection by the tools available to us here.

7.4 Exceptions to the semantic coercion principle.

The reader will probably have noticed in passing a certain number of exceptions to the principles of prediction and coercion.

a) abstract adverbs and adjectives

As we saw above when characterising the prediction principles, abstract adverbs and adjectives do not coerce the verbs and nouns they respectively stand in relation to. Abstract adjectives do not coerce nouns, probably because they are not intersective and thus our minds do not need to engage in that feature-unification meshing process that is necessary when we are confronted with intersective adjectives and the nouns they combine with, such as 'red hair'.

For example, the rather unusual 'adjective' 'John's', which is abstract since it is not apprehensible by the senses (one cannot apprehend, for instance, ownership), does not coerce nouns with which it combines to form a noun phrase. The following examples yield concrete, animate, mental and abstract noun phrases respectively.

John's ping pong bat
John's mum
John's opinion
John's date of birth

Compare also

the French onion
the French chef
the French orgueil
the French pre-eminence

It may be argued that this merely demonstrates that the noun is the syntactic and semantic head of a noun phrase, and it is therefore not surprising that adjectives of any semantic class should be coerced by the noun with which they combine. This explanation is, however, undermined by the fact that, on other occasions, as the coercion principle shows, nouns are apparently coerced by adjectives, or at least some kind of semantic negotiation goes on (inevitably the case in oxymorons). The following noun phrases demonstrate the anarchical potential of adjectives. The examples given are exceptions to the general rule that an abstract adjective can combine with any noun of an ontologically lower class without anomaly or coercion of that noun. It will be evident that the nouns in these examples undergo radical semantic change.

a pillar of society
moral high-ground
mathematical milestone
spiritual exercises
a technological brain (e.g. a computer).

b) materialisation

This is a rhetorical device beloved of, amongst others, the advertising industry in which an abstract term is used to denote a concrete object in the, perhaps mistaken, belief that it acquires a sublimity thereby, for example,

this delicious thatched home
these frilly ideas for christmas
the chitterlings were an unpleasant surprise
muscular Christianity
a chocolate creation
liquid poetry

I call these materialisations because, according to the semantic principle, the presence of an abstract noun should translate the whole noun phrase up into its abstract dimension. However, instead, it is materialised or realised in some physical manifestation. Thus a 'home' is really abstract but is materialised into a thatched building apprehensible by the senses. Likewise, the ideas are realised as visible frilly objects, the surprise is an incarnate one and the Christianity physical jerks. The chocolate creation and liquid poetry might be profiteroles and Bollinger '29.

Mental and animate nouns are also occasionally susceptible to this kind of reification:

a metal mind

(for example, a computer) yields a concrete noun phrase rather than a mental one. Likewise

a metal waiter

(for example, a trolley) yields a concrete noun phrase rather than an animate one. The latter is a curious usage which one could call anthropomorphism. Anthropomorphism is present in the following idiomatic phrases.

straw man
sleeping policeman
dumb waiter

c) ellipsis

Ellipsis is responsible for the fact that no syntactically correct concatenation of words is ever meaningless and moreover can sometimes be construed not in accordance with the above semantic principles. Wilks (Wilks 1973) agrees:

the space of meaningful expressions of a natural language cannot be determined or decided by any set of rules whatever - in the way that almost all linguistic theories explicitly assume CAN be done. That is because in common sense terms, a speaker [and more interestingly for us, a hearer] always has the option to MAKE any string of words meaningful by the use of explanations and definitions. However any working system of linguistic rules does implicitly specify a class of acceptable expressions, and so, indirectly, a class of unacceptable ones. The only way of combining these two facts of life is to have a modifiable system of linguistic rules...

More importantly an ellipsis may be the most immediate and commonsensical reading.

Fr Blaney discussed the black issue

probably concerns apartheid ('the issue about blacks') rather than an oil spillage, but it is not clear how we know this. Indeed it seems rather tortuous when we have a perfectly good concrete reading to do with spouting oil or some such thing. The explanation is probably to do with the syntagmatic requirements of the concrete sense of 'issue', for instance, that it occur in some frame such as 'an issue of X from the Y',

for example, 'an issue of gas from the faucet ' or the orotund 'issue of his loins'. Frequency of usage in the linguistic community must also affect our interpretation of certain phrases.

The soldier melted when Modeste sang 'Invictus'

is probably elliptical for 'the soldier's heart melted when Modeste sang 'Invictus''.

I decided to know that I had rickets,

probably means, I decided to confirm that I had rickets by talking to my GP, although it is an example of a fine grained anomaly.

Not all words can be elided successfully, for example,

Beasley has worked hard on his gerunds

is not, fortunately for Beasley, elliptical for

Beasley has not worked hard on his gerunds

As has been pointed out to me, the appropriate context or ironical intonation could derive the former sentence from the latter. However this derivation is not ellipsis.

d) metaphor

In figurative usage, the semantic principle applies, for example,

the thirsty bucket winked at the merry pump

As we have seen, figurative usage occurs when mental adjectives, adverbs and verbs (that is, ones concerning the psyche or the cognitive, emotional and intentional life of man) and animate adjectives, adverbs and verbs, occur in conjunction with concrete (that is, appertaining to inanimate matter) nouns, verbs and subject nouns respectively, resulting in a realm of androids and android-like events, for example

the peevish bicycle
output the document eagerly
the scythe repented
the talkative bacon-slicer
the tree tossed its leaves skittishly
the waves danced

Such anthropomorphic beasts usually populate children's stories and imaginative literature. Although the semantic principle applies to figurative usage, the class figurative is evanescent and more susceptible to coercion by an accumulation of subsequent text than other semantic classes are. In figurative usage the semantic principle may be overridden if the metaphor that has been set up is immediately anaesthetised by subsequent non-metaphorical material, for instance,

the thirsty bucket overflowed with fresh water

This is an example of the general rule that a sufficient accumulation of linguistic counter-evidence can override the semantic principle.

The phenomenon can occur when abstract and animate words are

combined as we have seen.

justice walked down the street carrying her golden scales
justice walked down the street in the form of the master of the
rolls

The latter is an example of a materialisation, that is,
'bewigged justice' (compare 'frilly Christmas ideas'), and
thus an exception to the semantic principle. The former is part
of an extended conceit or figurative scena. Thus the class
figurative is degradable and shows less tendency to coalesce
for good, as befits metaphorical usage which exhibits language
at its most elastic. It is not that the principle is not
broadly applicable but rather that semantic constructions may
be deliberately violated to give increased pungency of
thought. Sometimes metaphor is heaped on metaphor. In
Wordsworth's famous lines,

Surprised by joy -impatient as the Wind
I turned to share the transport

Wordsworth uses the wind as a simile for himself in impatient
mood. Wind however is not impatient (pace Boreas and co)
except anthropomorphically and metaphorically so.

Metaphors can, of course, be present at all ontological levels.
In our crude hierarchy, 'trumpet major' and 'dog' would both
be classified as animate, and 'wooden' would be classified as
concrete. However, 'trumpet major' has heavy overtones of
functionality while 'dog' has not. I suggest that this is why
'wooden dog' would resolve into the category concrete (this is

an example of a model and is dealt with below) while 'wooden trumpet major', due to the greater functionality or abstractness of 'trumpet-major', would resolve as animate.

e) lexicalisations or crystallisations of phrases.

Lexicalisations or crystallisations of phrases (for example, sleeping policeman, straw man, iron lady, tin soldier) must be considered as units as must all true idioms. Their resulting classes are an evolutionary matter.

f) symbolic representation of the abstract

The symbolic representation of abstract objects like works of literature and music affords them a concrete existence that runs counter to the semantic principle. Abstract objects such as songs, ideologies, novels, theories and ideas are often accessible to us through the physical medium of text or musical notation and also speech which is a physical medium. In this way potentially anomalous physical references to abstract objects are easily resolved. Thus

output a theory

under the semantic principle should yield an abstract verb phrase meaning something like 'made public a theory' but a more appropriate reading is 'printed a theory in physical symbols on a piece of paper'. Compare also

the novel fell in the bath

The dual status of 'novel' as an abstract object and a physical one allows the resolution of the verb phrase as a concrete verb phrase. Compare

tore up the song
Hippolyte told a story
what Mungo says is a lie

where songs, stories and lies have a conventional physical realisation, the first as sheet music and the other two as speech.

g) iconography.

Another kind of conventional code is iconography, especially the making of models. Thus, reference to the Virgin Mary could be to an icon of the Virgin Mary. Similarly, sculpted likenesses are made of a large range of people, animals and concrete objects reduced (or increased (the wooden horse)) in scale. Thus the following examples of anomaly can be painlessly resolved.

Raoul picked up the M.E.-109
the little shepherdess shattered into a thousand pieces
Caravaggio painted St. Jerome

h) oxymorons.

Oxymorons should be mentioned here since by definition the two components of an oxymoron fall under the same semantic class. This means that, according to the prediction principle, the

two elements are compatible and the semantic class of the oxymoron will be determined by syntax.

It is not clear what this could mean in the case of oxymorons. Obviously, in one sense there is no problem since the two parts of the oxymoron belong to the same class anyhow. However, given a finer-grained ontological typology they would not. It seems to me that, in those circumstances, semantic classification of the whole phrase would be impossible since the meaning of an oxymoron oscillates backwards and forwards between two poles: it is the nature of the beast to arrest the mind and paralyse thought.

It is interesting that, for some reason unknown to me, one would not consider the last example below to be an oxymoron although it seems to contain something of the oxymoronic about it. However, one's intuitions are borne out by the fact that it does not oscillate but one of its elements, namely 'water' is coerced into a different sense, 'ice'.

perpetual day
brief eternity
darkness visible
frozen water

Chapter 8. Entailment and inference.

8.1 Making domain-independent inferences from known words.

The third semantic assumption we are setting out to demonstrate is that domain-independent inferences can be made from the basic words of English. This means that, regardless of the subject matter being discussed, there are certain words that are basic to, or have a high frequency in, the English language and these occur in all domains and can be used to make inferences about those domains even though there may be a high incidence of unknown or technical words in the text as well.

Some justification should be given for attempting to account for inference when so many of the standard clues to semantic resolution are not ones at our disposal. I mean, of course, intonation, stress, prosody and all kinds of physical gesture. It seems to me, however, quite valid to consider textual semantics on its own provided that the interpretations one makes are not claimed to be true of spoken language.

It seems that often work is done on semantics without a specific disclaimer as to its applicability to speech but the dichotomy between the spoken and written word is an unembarrassing one. There is no doubt that writers and readers bring to bear on their respective activities different skills of perspicuity and receptivity from those that they would bring to bear when speaking and listening. A semantics of the

written word is a worthwhile endeavour.

The schema

X contains Y

may be realised as

the book contains a photograph
the theory contains an argument
the picture contains a skull
the bottle contains Vimto

and so on, but in all these cases a part-whole relationship may be assumed. No matter what domain is under discussion, the verb 'contains' suggests a particular kind of scenario in which the parts of some whole or the contents of some receptacle or frame are being discussed. Thus, certain domain-independent inferences can be made and the questions

does X contain anything else?
what else does X comprise of?
what is X a part of?

and so on, are appropriate. (Of course where a word has more than one sense, for example 'contains' in

the bucket contains two gallons

(that is, 'the bucket will hold two gallons'), we would expect different inferences to be appropriate.)

There are many problems of course. One cannot expect always to abstract relations cleanly from their arguments, irrespective

of topic and focus. For example,

X is between Y and Z

might suggest a range of inferences about spatial properties and adjacency. In many cases the question

what is the other side of Z?

would be appropriate. However, consider a conversation about the contents of a room that included the sentence

Arthur is between Stanley and the wall.

To ask

what is the other side of the wall ?

would be to step outside the domain.

We will go on to consider in detail the kinds of domain-independent inference that can be made from a corpus of basic English words.

8.2 Logical entailments: making inferences with no turning ----- back. -----

We saw above that selectional preferences are important to this work because we need to predict the meaning of unknown words from known ones. Semantic coercion is important to this work because sometimes language incorporates some kind of so-called category mistake, as in the second example.

Berensen travelled widely in Peoria
Berensen spoke widely of pyorrhoea

The third semantic mechanism important to this work is lexical entailment or making inferences from propositions.

It is useful to distinguish two different schools of semantics which, although not fundamentally incompatible, have not been synthesised in a formal way. We might call these logical semantics and lexical semantics. The former converts natural language into logical form and is concerned with logical entailments. (This is somewhat begging the question, as Quine (Quine 1972) suggests, that logical form is the form of an argument not a statement or a proposition, that is, your choice of logical form will constrain the entailments you can subsequently make. This however does not worry linguists since one still has the opportunity to compare the entailments of a logical representation of a sentence with one's own intuitions about its entailments.) The latter is concerned with lexical semantic entailments.

Logical semantics has its origins in Aristotle's work on the syllogism (Ackrill 1987):

when you predicate this thing or that of another thing as of a subject, the predicate then of the predicate will also hold good of the subject. We predicate 'man' of 'a man', so also of 'man' do we predicate 'animal' therefore of this or that man, we can predicate 'animal' too. For 'a man' is both 'animal' and 'man'...

Neither logical nor lexical semantics can give an exhaustive

account of meaning on its own.

Cruse (Cruse 1986) uses the word 'entailment' to mean Lyons' 'pragmatic implication' (Lyons 1977) rather than a truth=conditional notion. Cruse's strategy is contextual not model-theoretic:

the meaning of any word form is in some sense
different in every distinct context in which it
occurs.

Cruse does not want to abandon compositional semantics (indeed he says it is indispensable) but to emphasize how some semantic traits come to the fore when a word is used in one context and retreat in another context.

The meaning of 'butter', for example, in the sentence

Gladys poured the butter into a dish

is a valid one but atypical. It acquires the property of being liquid because it is the object of 'pour'. This is not to say however that its meaning has changed in context (a slippery slope) but merely that we select some of its total possible traits and give up others.

There may be 'mutual negotiation' between a number of words in a sentence until each has a subset of semantic traits that is compatible with all the others. (Such a negotiation is achieved by term or graph unification in some parsing machines.) The impossibility of this strategy solving curiosities like 'swallow the lie', and how unification is

inadequate in resolving anomaly, has been discussed above.

We should bear in mind that Cruses's entailment is a cancellable inference dependent on context for its force.

Cruse's research method is to discover entailment by looking at the degrees of normality and abnormality in ordinary language expressions or diagnostic frames such as 'Xs and other Ys'.

When one gets used to this method one realises how delusive abstractions are, as Cruse's examples show. Consider 'X is colder than Y' and 'Y is hotter than X'. A lot of people would consider that mutual entailment obtained between these two sentences. However a judicious choice of noun-phrases sows seeds of doubt, for example,

my fridge is colder than Glad's fridge

and

Glad's fridge is hotter than my fridge.

Types of entailment identified by Cruse are:

- unilateral entailment: 'X is a dog' unilaterally entails 'X is a non-human animal'; 'animal' is a criterial trait of 'dog'; this is hyponymy;
- mutual entailment/logical equivalence: 'X began at 10 am' entails and is entailed by 'X commenced at 10 am';
- contrariety: 'X is a dog' stands in a contrary relation to 'X is a cat', that is, 'X is a dog' unilaterally entails 'X is not a cat'; 'cat' is an excluded trait of dog;
- contradiction: 'X is dead' entails and is entailed by 'X is not alive'.

Since Cruse's notion of entailment is more akin to pragmatic implication than to logical entailment, presumably the above entailments must be deemed cancellable. It is clear that entailment is not as dependable a notion as one might hope. Can we discover any kinds of inference that are uncancellable?

A simple distinction can be made when making inferences, namely, between logical ones and lexical ones. This dichotomy may seem an over-simplification to some. Standard accounts of inference would enumerate at least six different kinds of inference. I have added more, in the knowledge that there are many more varieties of 'jumping to conclusions'.

propositional calculus

for example, 'Vernon trembles and Arthur trembles'
implies Vernon trembles;

predicate calculus

for example, 'one man is not a plumber' implies that it
isn't true that all men are plumbers;

presupposition

for example, 'Vernon's wife is not a bookie' implies
Vernon has a wife;
'Wilton Catford wasn't at the maths convention' implies
Wilton Catford exists;
'Mrs Thrale knows Samuel Johnson is a Jacobite' implies
Samuel Johnson is a Jacobite;
'Ida Nettleship made Augustus John happy' implies
Augustus John was happy;
'Father Blaney's soutane barely reached his shins'
implies Father Blaney's soutane reached his shins;
'Gatting has done it again' implies Gatting has done it
before;

deixis

for example, 'I went to Cowdenbeath' implies that I am
not there now;

logico-lexical

'it is Thursday' implies that it may be Thursday;
'James Joyce's wife is Norah Barnacle' implies that
Norah Barnacle's husband is James Joyce;
'Pitsligo is older than the Bonny Prince and the Bonny
Prince is older than Butcher Cumberland' implies
Pitsligo is older than Butcher Cumberland';
'I have exactly two' implies I have at least two and I have
at most two (see Hodges 1983);

lexical

for example, 'Bim is a goat' implies Bim is a mammal;
'Grapelli plays the fiddle' implies Grapelli plays the
violin;
'I can hear something if it makes a noise' implies that I
can hear something if it is noisy;

pragmatic

for example, 'Arthur had a pie but he didn't eat it'
implies Arthur usually eats his pies;
'I can do it in 10 minutes' implies I can do it in at
most 10 minutes;
'I can lose a stone by Christmas' implies I can lose at
least a stone by Christmas (Cruse 1986);
for example, 'some of them don't' implies some of them do;
'there is one sock on the meatsafe' implies there is only
one sock on the meatsafe;
for example, the advertising slogan for grey salmon: 'the
only salmon that doesn't go pink in the tin' implies all
pink tinned salmon is unnaturally pink;
for example, 'Blaney is not unmarried' implies Blaney is
married;
for example, 'Vern and Art picked it up and Art bit it'
implies Vern didn't bite it;
'Modeste touched my nose' implies that Modeste touched me;

irony

for example, 'Fons is an intellectual; he's even heard of
Plato' implies Fons isn't an intellectual;

hyperbole

for example, 'I am a greater thinker than Plato';

metonymy/synechdoche

for example, 'I drink a cup every night' implies I drink
the contents of a cup;

meiosis/litotes

for example, 'it was slightly imprudent to eat that haunch of condemned veal' implies that it was foolhardy to eat that haunch of condemned veal;

epizeuxis

for example, 'he was a long long time in there' implies he was a long time in there;

prototypical

for example, 'Bimbo is a scottie' implies Bimbo can bark;

induction

for example, 'Vern quivers and Beat quivers and Art quivers' implies everyone quivers.

We can preserve our dichotomy by dividing these inferences into cancellable and uncancellable ones. Some would say that the first six types of inference are not cancellable without contradiction while the rest are cancellable. Here are some example cancellations of the first six types of inference that do not work.

Hippolyte and Victoire ate it but Hippolyte didn't eat it
this woman hasn't got one but all women have got one
Ida made John happy but he has always been as miserable as sin
I went here last Tuesday
it's Tuesday but it probably isn't
Bim is a goat but he isn't an animal

Here are some example cancellations of other types of inference that do work.

Arthur had a pie but he didn't eat it but then he never eats
them
there is one sock on the meatsafe and another beside it
Vern and Art picked it up and Art bit it and Vern bit it too
Bimbo is a scottie but he can't bark

Vern quivers and Beat quivers and Art quivers and Bim doesn't
quiver

None of these examples is contradictory.

Before considering cancellable inferences we will look at the
uncancellable ones.

Deixis is an interesting phenomenon. Deictic expressions
exert very powerful entailments that it is difficult to cancel.
One might say

I went to Dingwall and Cowdenbeath looking for work and ended
up here in Cowdenbeath.

This is infelicitous but perhaps acceptable. Likewise one
might say

I went to the lavatory before elevenses

while standing in the lavatory, though this is probably only
allowable because 'going to the lavatory' is a euphemism for
micturition.

Deictic expressions and temporal ones seem to provide some of
the strongest candidates for uncancellable inferences.
Violations of temporal linearity, although not meaningless,
have the status of puns.

A man from the Isle of Wight,
Travelling much faster than light,
Set off one day
In a relative way,
And came back the previous night.

Compare also

last night, as if we hadn't had enough this morning, it rained

Another possible contestant for the uncancellable inference is provided by paronymy.

Paronymy is the relationship between one word and another belonging to a different syntactic category and produced from the first by derivation, for example 'wide' and 'widen'. (We might include here composition too, for example 'apple' and 'appletree'.) This is of obvious importance in an inferencing machine as it is likely that one would want to make the same inferences from a base form and from some of its paronyms or composites. For example, 'noise', 'noisy', 'noised abroad' and 'noisily' are all concrete terms in that they are apprehensible by the senses. This is not invariably true however. Some forms of a word are reserved for abstract usage, for example 'noisome'. Parsing systems built on a feature based formalism often associate some features with the stem that can be adduced automatically to any word having that stem.

Epizeuxis of certain kinds has the effect of shifting a sentence that might feasibly have been cancellable up the scale to uncancellable heights, for example,

Father Blaney will never never blaspheme again
Metropolitan Antony had a long long beard
the marmalade is gone, gone

8.3 Lexical entailments: making inferences and changing one's ----- mind. -----

Others would say the dichotomy really comes between the first three and the rest: propositions incorporating deixis and implying hyponymy relations being as synthetic as the rest. Thus, we might be able to conceive of a situation where we found a species we wanted to call a goat but not a mammal.

Indeed Quine in his famous paper 'Two Dogmas of Empiricism' (Quine 1951) argued that we could not allow the analytic/synthetic distinction since scientific knowledge is like an interconnected web with no part immune to revision in the light of experience. Virtually any feature can be taken away from a category (for instance, hardness could be taken away from diamonds) but when some features are removed a global re-organisation of one's knowledge is necessary. The larger this re-organisation, the more analytic and defining this feature is. There is a continuum of analytic to synthetic truths rather than a dichotomy.

Austin was another who did not believe in the distinction. With regard to the following

this noise exists
this smell might not have existed

he would say, one might call the former analytic since existence is part of the meaning of 'this'. However, the latter is not contradictory, therefore existence cannot be part of the

meaning of 'this'.

Moore finds analyticity hard to detect. The following

what is good ought to exist

he describes as synthetic but impossible to conceive as being false. He prefers the Kantian class of synthetic a priori knowledge. Other examples of this are

pink is more like red than black
the noise existed but was not heard

Kripke takes a different line with natural kind terms referring to them as 'rigid designators'. This would render terms like 'goat' and 'water' 'rationally unrevisable' in the sense that once one has discovered that water in the actual world is H₂O, then nothing would count as a possible world in which water was not H₂O. Thus the term is 'epistemically necessary' (Putnam 1973). Putnam points out that, in a curious sense, words like 'water', have an unnoticed indexical component, that is, 'water' is stuff that 'bears a certain similarity relation to the water around here'.

It appears that Cruse restricts himself to natural kind terms and uses a contextual frame or schema to identify hyponyms, namely, A is f(X), where f(X) is an indefinite expression and a complement of the verb 'to be'. The alternative is 'f(X) is necessarily f(Y)'. If 'A is f(X)' entails 'A is f(Y)' then X is a hyponym of Y and Y is a superordinate of X, for example,

'this is a dog' unilaterally entails 'this is an animal';
'this is a stallion' unilaterally entails 'this is a horse';
'this is scarlet' unilaterally entails 'this is red';
'this is a man who murdered' unilaterally entails 'this is a
man who killed'.

Other useful constructions suggesting hyponymy include

Xs and other Ys,
no X more Y than a Z,
all Xs except Ys,
I like Xs - mostly Ys.

Cruse claims they can be indicative of other relations however,
for example, under his definition of hyponymy

the following do not qualify,

dogs and other pets,
there is no weapon as versatile as a knife.

This seems to me to be slightly debatable. An alternative
reading would be that the presence of a hyponym-suggesting
construction (for example, 'and other') actually coerces the
noun phrases into a relation of hyponymy (not a natural kind
relation of course). Thus, we must take our speaker to be
speaking only of pet-dogs in the former and only of
weapon-knives in the latter. Why else would he use the
construction 'and other'?

The coercive power of words is central to the present thesis. I
tried to convince a colleague once that the frame 'He's an X
but he isn't a Y' implied Yness was an expected trait of Xs.
Such is the coercive power of 'but' that no matter how absurd
the values for X and Y suggested, the rule obtained. 'Stan is

a traffic warden but he isn't a plumber' can only make sense in an appropriate discourse context where plumberhood is a natural concomitant of trafficwardenhood. (Stan while issuing parking tickets is asked to plug a leak in a milk tanker.)

Cruse points out interestingly that the direction of entailment is reversed when the hyponym and superordinate fall within the scope of a negative or universal quantifier, or they form part of a conditional clause or other expression of contingency, for example,

'it isn't red' entails 'it isn't scarlet';
'all animals are forbidden' entails 'all dogs are forbidden';
'without the red ones there will still be too many' entails
'without the scarlet ones there will still be too many';
'if it's red it won't do' entails 'if it's scarlet it won't do'.

In the following two examples neither the hyponym nor the superordinate falls within a negative, there are no universal quantifiers or conditionals and so the hyponym precedes the superordinate:

'I don't like this scarlet one' entails 'I don't like this red one';
'I like this scarlet one' entails 'I like this red one'.

I am not sure about Cruse's point concerning universals though; for one thing the scope of the universal quantifier is the same in both of the following:

'all animals are forbidden' entails 'all dogs are forbidden';
'all pimpernels are scarlet' entails 'all pimpernels are red';

namely

for all X (animal(X) -> forbidden(X));
for all X (pimpernel(X) -> scarlet(X)).

However, in the former entailment the superordinate precedes the hyponym as Cruse predicts while in the latter it is the other way round. It seems from this and subsequent examples that Cruse's idea of scope is not logical scope but something more like immediate adjacency, or what he calls 'field of action'. He says that if any two of the above features (universal quantifier, negative, conditional) co-occur then entailment is in the 'normal' (that is, hyponym-superordinate) direction. However consider the following:

'it isn't true that all dogs have fleas' entails 'it isn't true that all animals have fleas';
'it isn't true that all dogs have parasites' entails 'it isn't true that all dogs have fleas'.

Consider also:

'dogs don't have parasites' entails 'dogs don't have fleas'.
for all X for all Y (dog(X) and parasite(Y) -> not have(X,Y))

I am not sure what Cruse would predict here. Two of his features are simultaneously applicable (that is, negative and universal); a conditional is also present if one accepts predicate calculus' rendering of universals in terms of conditionals. Cruse says the presence of three of the features yields the superordinate to hyponym order. This is his example.

'if not all vehicles are forbidden I shall go' entails 'if not all cars are forbidden I shall go'

This is complex logically but it does seem that it is not enough to talk of features being simultaneously applicable. We need to know the scope of these features as logical operators before we can predict hyponymy relations.

To leave the scope of quantifiers for a moment, Cruse points out appositely that detecting quantifiers in the first place can be tricky. The following show how implicit universal quantification (in 1 and 3) and implicit existential quantification (in 2 and 4) govern what entailments are possible.

- 1 'it is important to avoid red socks' entails 'it is important to avoid scarlet socks';
- 2 'it is important to buy red socks' does not entail 'it is important to buy scarlet socks';
- 3 'flowers are prohibited' entails 'dandelions are prohibited';
- 4 'flowers make an acceptable present' does not entail 'dandelions make an acceptable present'.

Two points should be made. It is certainly true that we disallow entailment in 2 and 4 but it is not proscribed by logic. It is comparatively easy to contrive a context where it was important that whenever one saw any red socks one should buy them up. This would then include the scarlet ones too (likewise the dandelion bouquet: 'you said you wanted flowers darling and these are flowers').

The second point is that, presuming that such sentences are not ambiguous and that one has a parser that can render such sentences into logical form correctly (and that is to presume a lot), then there is no ambiguity about what can or cannot be

entailed. It is flippant to dismiss these wonderful examples though. The flowers example could be explained nicely by Rosch's prototypical concepts. A dandelion is not plumb in the middle of the prototypical concept of flower but rather peripheral. In the socks example (example 2) there seems to be an implied existential quantifier, that is 'some socks'. 'I like some red socks' doesn't entail 'I like some scarlet socks'.

It has been suggested to me that a negatively charged verb suggests a universal reading of a sentence. Positively charged verbs however do not always suggest an existential reading. The two fragments (imagine them as memos on the kitchen wall) 'buy prunes' and 'avoid prunes' are indeed existential and universal respectively. However, in the following examples the positively charged verbs suggest universal readings.

it is the gallery's policy to buy Picassos offered to it for sale (i.e. all Picassos offered to it for sale)
stamp library books when they are issued (i.e. all library books)

It is harder to find examples of negatively charged verbs that suggest existential readings. The following examples however suggest existential readings ('certain records', 'some pupils' and 'some weight' respectively):

successful runners break records
you must fail pupils in order to preserve the credibility of the examination system
lose weight

The paradoxical

ignore imperatives

might seem to force an existential reading ('certain imperatives') to defeat its paradoxicality, but this is a mistake. It is the implied universal ('all imperatives') that enables us to recognise it as a paradox in the first place!

Cruse gives some examples of curious entailments which cease to become problems when rendered into logical form. For example, he says that there is not the expected entailment between the following.

Mary was disappointed to receive a rose
Mary was disappointed to receive a flower

This is because, despite the apparent reference to an existential rose, there are implied universals in both sentences, that is,

Mary was disappointed to receive any rose
Mary was disappointed to receive any flower

or,

for all X (rose(X) -> kindofthingMarydisappointedby(X))
for all X (flower(X) -> kindofthingMarydisappointedby(X))

Cruse has told us that universals reverse the direction of hyponym-superordinate so we should not expect entailment here.

Hyponymy is one of Cruse's four types of entailments. However, Cruse's entailments are only binding in certain situations, the most convincing being the mutual entailment of synonymy.

While 'commence' and 'begin' usually belong to different linguistic registers, nevertheless this entailment is fairly uncontroversial. The others are slightly less so.

'Dog' in vulgar usage can be applied to a man or a woman; 'cat' is sometimes used disparagingly of a woman. Thus a dog might be human and also a cat! Likewise all that is not alive is nevertheless not necessarily dead. As we saw above, negation does not commit itself to any particular axis.

Thus, the process of detecting hyponymous relations in fragments of natural language can be tortuous and we must accept that the effort may not pay anyway in that hyponymous relations may always be cancellable.

Another lexical relation that generates cancellable inferences is taxonymy. Taxonymy is similar to hyponymy. Cruse suggests taxonyms are akin to natural kind terms, and non-taxonomic hyponyms to nominal kind terms. (Natural kind terms share with proper names the property of being rigid designators. This means their referents would retain their labels whatever changes to their nature came about, for example, 'cat', 'horse'; contrast 'stallion', 'spinster'.)

Taxonymies can be characterised by the good category principle (Cruse 1986; Rosch 1978). Subdivision is based on categories with the highest possible degree of resemblance between co-members and the maximum possible distinctiveness between different categories.

Certain general characteristics of taxonomies are suggested by Cruse. They typically have no more than five levels. For example:

unique beginner	plant
life-form	bush
generic	rose
specific	hybrid tea
varietal	Peace

Most everyday words are at the generic level and most branches end at this level. Every branch does not necessarily have nodes at every level. This may be because of conceptual gaps (for example, 'animal'-'dog'-'spaniel'; 'bird'-?-'fieldfare') or because of lexical gaps ('possessions' - 'wearables' - 'wristwatch').

Rosch has named those items regarded as better examples of a category than others as 'prototypes'. (Prototypicality should not be confused with common usage: 'think of an odd number' is far more likely to prompt '3' or '5' than '24681'.) For instance, Cruse claims that a bag of clothes may include shoes but not to the exclusion of anything else. Some really prototypical elements must be present (like trousers) and they will somehow carry the more peripheral members of the category which are optional.

This seems slightly debatable. A bag containing shoes and a hat would be a bag of clothes, although shoes and galoshes might not be. However, it all depends on the diversity of objects in the domain. If there were bags of all sorts of

things like saucepans and tinned fruit it would seem quite in order to classify a bag of shoes as clothes.

Co-taxonyms are, by and large, incompatibles but this is less true for verbs. Cruse points out that they seem to be more context-dependent than nouns.

Items at the higher levels of a taxonomy may often be mass-nouns (for example, 'cutlery') although lower levels contain count-nouns (for example, 'fork').

Taxonyms may be indicated by the frames

X is a kind/type of Y
Xing is a way of Ying

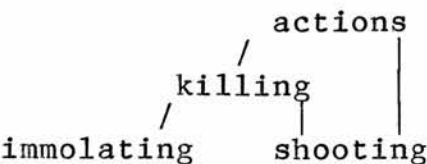
Thus

a spaniel is a kind of dog
gliding is a way of flying

(However, note that 'a spinster is a kind of woman' is felicitous but does not refer to a natural kind term.)

Taxonyms are not always hyponyms, again suggesting a lattice. Consider,

'shooting is a way of killing'.



Sometimes there are lexical gaps where conceptually we could do with a word. This is linguistically quirky but not an insuperable hurdle. For instance, Cruse points out that there is no superordinate of the right category for 'knife', 'fork' and 'spoon' but only the quasi-superordinate mass-noun 'cutlery'.

Similarly, there is no superordinate for 'red', 'blue', 'yellow' and so on. 'Coloured' might seem to do but in some circumstances this would include 'black', for instance, if one were sorting glass for salvage into clear glass and coloured glass, black glass would be considered coloured. Again the context elucidates. Where we expect transparent objects then black ones are deemed coloured. Where we expect the colours of the spectrum then black objects are deemed not coloured.

It seems that an analysis of taxonyms is fraught. The process of distinguishing them from hyponyms is attended with problems; there may be linguistic gaps that render inference impossible and, moreover, taxonymies, like hyponymies, do not generate uncancellable entailments.

The lexical relation meronymy or parts-explosion can also generate inferences, for example,

'the bee is on John's elbow' entails
'the bee is on John's arm',

Meronymy generates a kind of branching hierarchy. Cruse tells us that the relation is transitive, asymmetric and catenary.

Parts (that is, components as opposed to smithereens) are autonomous (that is, they have an identity independently of the thing they're a part of), have non-arbitrary boundaries and a function with respect to the whole.

He also observes that a meronymy should consist of elements of the same type. We have a choice. For example, the human body could be defined anatomically or systemically (that is 'head'-'body'-'legs' or 'muscles'-'nerves'-'bloodvessels').

The most inclusive term is never missing in a meronymy as it may be in a taxonomy although it may be the same as one of the parts, for example the part of a teapot that holds the tea is the teapot.

Meronymies vary in a number of ways. They may be non-concrete (for example, processes); they may be poorly differentiated (the members of a team); they may be undifferentiated (the members of a unit of measure); they may have no structural integration (the stones in a heap). They may also vary between count-nouns and mass-nouns. Cruse identifies four types, namely,

count-count (for example, tyre-car);
count-mass (for example, grain-sand);
mass-count (for example, steel-car);
mass-mass (for example, milk-custard).

It is clear that these examples are very different. The third partakes of the mass-form distinction identified by Aristotle as exemplified in a marble statue (the statue is the form; the

mass is marble). This of a very different nature from the parts-explosion (tyre-car) kind or the disintegration (grain-sand; milk-custard) kind and the random-disintegration (cake-crumb) kind.

Meronymies may not have a constant relation all the way down the hierarchy. Now it is clear that some items stand in a strict part-whole relation while others do only partially. The tell-tale constructions (both of which must be present), that Cruse suggests, are

Xs are parts of Ys
Ys have Xs

Examples that fit one frame but not the other, such as

sounds have pitches
his beard and moustache are part of his attraction

are not examples of meronymies.

A composite frame is:

the parts of an X include the Ys, the Zs etc.

Here is an example.

fingers are parts of hands; hands have fingers
indices are parts of books; books have indices

The former shows strict meronymy, the latter only partial meronymy because there are books that don't have indices and indices that are not part of books. There are of course hands that do not have fingers in the same way that there could be

non-stripy tigers (suffering from alopecia) but it is useful here, as elsewhere, to distinguish natural kind terms from others.

Sometimes the frame produces odd results.

the house has a door
the door has a handle

We cannot say however that the house has a handle. A handle may be more properly defined as an attachment. (Compare head-ear; arm-hand; door-handle.) Transitivity is affected by such relations. For instance, Cruse claims

'Fred has a head; the head has ears' entails 'Fred has ears'

but

'I touched the ears' does not entail 'I touched the head'.

It seems a slightly moot point whether touching someone's ears involves touching their head. It is certainly true that one can say, without contradiction,

touch Fred on the ears not on the head

Curiously enough, what is not a moot point is that to touch Fred's ears is to touch Fred.

Temporal structures may also have parts which do not necessarily satisfy the above conditions for meronymy. Here are Cruse's excellent examples.

the most popular part of the show is the strip-tease
the run-up is part of the action of bowling
the best part of the show was the decor
learning to be patient is part of growing up
bowing is the hardest part of playing the violin
being slim is part of being fit
Christmas pudding is part of Christmas

Groups are a bit like meronymies, for example family,
orchestra, congregation. They have functional cohesion, for
instance,

a juror is part of the jury

Classes are also similar. They have a cohesion by virtue of
attributes.

a bishop is part of the clergy

Collection-membership is similar.

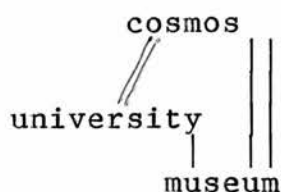
a forest has trees
a library has books

Cruse says there are four possible meronymic relations between
the holonym and the meronym, namely

they both necessarily co-occur ('body' and 'ear');
the whole can occur on its own ('newspaper' and 'leader');
the part can occur on its own ('fungus' and 'lichen');
they can both occur on their own ('university' and 'museum').

At this point we may be feeling rather confused but suspect
that there is some cognitive structure that would represent
these relations. It seems that a lattice would suffice with
two kinds of link in it, namely 'has part of' and 'has
optional part', for example (the label of the top node is

unimportant)



====>has part
——>has optional part

This approach will handle Cruse's other examples but not one that he does not mention, namely mutually exclusive parts, for example

the car has a hatchback or a boot but not both

Other associated frames are

X is an ingredient of Y
X is a constituent of Y

We saw that 'the door has a handle' and 'the house has a door' do not entail 'the house has a handle'. Suffice it to say that meronymy, like hyponymy, is a cancellable inference.

However, for our purposes it is significant that the questions

what is X a part of?
what are the parts of Y?

may yield varied and numerous answers.

8.4 Exploiting inferences.

Our aim is to generate inferences from the user's input. This means we cannot afford to restrict ourselves to logical

entailment. We would also like to make lexical inferences ('mother'-'child'), presuppositions, expected traits ('dog'-'bark') and so on. We may even find speech act theory is applicable to some input to the extent that typed input shares some characteristics of spoken language.

Now, this may not seem a problem in principle. It surely just means building a bigger inference engine and having more rules. The difficulty is knowing where in the system shown below to include the inference engine. (Upper case refers to bits of machine; the lower case is data.)

string->PARSER->phrase structure tree->LOGICAL MACHINE->logical form

Suppose we have the following chatty input and can parse it.

Vernon is I grant you a plumber but all plumbers really hate water

It is clear that a logical inference can be made from scalar particles (for example, 'even') although they do not affect truth conditions. Here we can infer that Vernon hates water. Other inferences can also be made, for instance, that plumbers are expected to like, or be dispassionate about, water. The trouble is, by the time the system has made its logical inferences, that is, after the logical form has been built, it is too late to make the lexical ones. Here is a fairly uncontroversial predicate calculus rendering.

plumber(vernion) and [allX(plumber(X) -> hates_water(X))]

What has been lost? The answer is the following constructions: 'I grant you', 'but' and 'really'. Other words of this kind include 'although' 'still' and so on. They are lost because in truth conditional semantics their inclusion makes no difference to the truth value of the proposition. It is clear that we shouldn't wait until this stage to make our lexical entailments. Can we move our inference engine backwards to an earlier point in the analysis of the string? This isn't possible either. One cannot make logical inferences until ambiguities of quantifier scope and so on have been sorted out and this has not been done at the phrase structure tree stage. The solution is that the parser and grammar should be sophisticated enough to handle these linguistic and semantic complexities.

It should be said that the representation of some inferences is not trivial. Leech (Leech 1983) claims that the process by which implicatures are recovered

is not a formalised deductive logic but an informal rational problem solving strategy

and that

all implicatures are probabilistic.

Levinson (Levinson 1983) claims that in some respects implicatures

appear to be quite unlike logical inferences and cannot be directly modelled in terms of some semantic relation like entailment.

Compare also Brown (Brown 1983) and de Beaugrande (de Beaugrande 1981). It is not clear though that implicatures might not be represented as lexical information albeit of a complex nature.

It is also worth pointing out that human inferring is not restricted to these rather mechanical processes. 'Jumping to conclusions' implies not only speed and athletic ability but also distance. Someone's response to my utterance may require a tortuous ratiocinative process on my part to wrench it into the semblance of relevant discourse, for instance (Sperber 1986),

would you like to buy a flag for the royal national Lifeboat Institution?
no thanks, I always spend my holidays with my sister in Birmingham

Some propositions produce curious entailments for which no principled account can easily be given, for instance,

the astronaut entered the atmosphere again
when Diggins knocked the stirrup-pump over he picked it up again
this is the red pencil

These are certainly a problem because they confuse entailment. One might argue that the first example is almost idiomatic. (The assumption is that it is the astronaut's first space trip.) It is clearly not literally true. To redefine 'enter' as 'to be inside' is to misuse the word. But, under normal conditions, to do something again entails we have done it already. It could be suggested that 'again', like some

metaphors, is selective as to the features of the action that are being repeated. Thus the astronaut didn't enter again but was inside again. The second example would have a similar explanation.

I am not sure about this. If this is the case why is it untrue to say 'I have had apple crumble again today' when I have only ever had apple pie before. It seems possible that 'again' is comparable to other words with a logical function like 'not'. There was widespread usage before the twentieth century of double negatives for emphasis rather than for the cancellation effect that is taken for granted now (except in vulgar usage: 'I didn't never take it').

The third example is more interesting. It is correct usage (and, more to the point, has only one standard predicate calculus rendering) but is ambiguous. This also confuses entailment and is an example of a much wider problem namely the ascription of properties to wholes when they are only properly ascribable to parts. This problem is akin to metonymy, for example 'I drank three bottles'.

Such subtle inference mechanisms are beyond the scope of this thesis.

Conclusion.

The adequacy of the theory.

There seem to be philosophical grounds for believing in the fundamental premise of this theory: the supremacy of abstract over concrete senses. For one thing everything has an abstract dimension, functionality or significance to human beings (this is true even of the most apparently inert concrete masses like sand), while not everything has a concrete manifestation. Thus at a very fundamental level, unification of abstract and concrete will always yield the former.

The other main reason is more an evolutionary one. Some words have both a physical and an abstract dimension because they have acquired the latter through longstanding metaphorical usage, for instance, 'warm' and 'cold' were used to name sensations before they were extended to refer to personality traits. Reference to sensation is earlier historically and also earlier in the child's acquisition of vocabulary.

To what extent can the principles of semantic prediction and coercion, outlined above, be part of a theory?

A scientific theory or research programme should provide
(Lakatos 1978):

a set of rules invariant over time and context;
a method of falsifying these rules;
a mechanism for prediction;
empirical evidence in support;

the absence of a simpler theory of equal explanatory power;
a description or classification of the domain over which the
rules obtain;
a classification of the complement of the domain.

Nowhere has it been claimed that the above theory is a scientific one. Demands for supporting evidence and falsification techniques are, in my opinion, inappropriate when the subject under examination is language, an exceedingly curious phenomenon unlike most in the natural world. Granted, human language shares with human locomotion that unruly element called human will. But it is yet to be demonstrated that there are any ruly elements in language, in the way that human locomotion is constrained by, say, rules of gravity, and surely if any rules were proffered, the imp of the perverse could immediately break them. We do not have this licence with the rules of gravity. Thus, it is not clear what could constitute proof that a given semantic interpretation was the correct one. For example, the coercion principle in our theory predicts that the following sentence concerns an abstract process.

Beasley exposed the drug-trafficking

This seems intuitively correct but what would constitute 'empirical evidence in support'? Perhaps a subsequent clause such as 'over the telephone' would do? One cannot literally expose things over the 'phone because it isn't a visual medium. However, one can expose pictures over the mantelpiece so, conceivably, one can expose some concrete realisation or physical depiction of drug-trafficking over the telephone.

This is an unlikely reading but we have got no proof either way. For the same reasons, falsification techniques are inappropriate too.

How are the other criteria satisfied? The absence of a simpler theory of equal explanatory power has been addressed in Chapter 5 where the inadequacies of other theories are discussed. A description of the domain and its complement is given in Section 4.7. The 'mechanism for prediction' forms part of the 'set of rules invariant over time and context' which is provided in Chapters 6 and 7. Thus, the concerns of empirical science have been embraced while its claims are viewed with some scepticism.

Improvements to the theory, bearing in mind its higher level aim of intelligent knowledge elicitation, would include principles of resolution of fine-grained anomalies, a facility for non-monotonic resolution due to an accumulation of counter-evidence, top-down discourse schemata and a mechanism for inter-sentential inference.

We have discussed the strategy of the program under those circumstances where some of the user's input is known to the program. On occasion no words of the user's input are known. Where no words are known, the system takes the first unknown word F, say a one place predicate, goes to the top of the lexicon lattice and asks the user whether the word is a noun, adjective or intransitive verb.

On other occasions all the words in the user's input are known. Under these circumstances inferences of the kind discussed in Chapter 8 are invoked, or, failing these, so-called 'external' questions are formed. These relate not to the semantic relations of intra-sentential words but to logical relations of entities in the domain under discussion. Here are some questions from Nida (Nida 1975) that might be deployed when all the user's input is known.

What is X like?
How is it used?
What does the entity look like?
What does the entity sound like?
What does the entity feel like?
What does the agent do?
Where does the agent live?
How does the agent act?
How is the artifact made?
What is the artifact made of?
What is the artifact used for?
Who brings about this event?
How does he do it?
With what does he do it?
To whom does he do it?
Where does he do it?
Who can be an X?
What can be an X?
Can you do something Xly?
Can you go X?
Can you talk Xly?

Appendix 1. Table of influence and coercion.

The theory provides the following information for each word in its basic English lexicon:

- a) the class and part of speech of the word;
- b) which part of speech it combines with to yield which part of speech;
- c) what class it predicts for the part of speech it combines with;
- d) what parts of speech/classes it coerces to produce what;
- e) what parts of speech/classes coerce it to produce what;
- f) verbal description of the word;
- g) examples;
- h) exceptions.

Abbreviations:

A = animate; M = mental; C = concrete; B = abstract;
F = figurative.

n = noun; v = verb; adj = adjective; adv = adverb

An -> C means that when the word in question is combined with an animate noun it yields a concrete phrase.

Table of influence and coercion.

- 1 Item. Concrete adjective
- 2 Structure it gives in composition. Adj + Noun -> NP
- 3 Categories it predicts for word it combines with. concrete or animate
- 4 Categories coerced by it. None.
- 5 Categories that coerce it. Mn -> M; Bn -> B
- 6 Verbal description. In a conflict between adjective and noun, a concrete adjective is always coerced by higher categories.
- 7 Examples.
wooden traffic warden -> A
green thoughts -> M
cast-iron theory -> B
the empire, in its pinafore -> B
metal theory -> B (i.e. theory concerning metal)
metal man -> A (i.e. scrap metal merchant)
a black humour -> M
black humour -> B
a black thought -> M (e.g. a thought about blacks)
a black campaigner -> A (e.g. a campaigner for blacks)
a black theory -> B (e.g. a theory about blacks)

- 8 Exceptions.
 - tin soldier -> C (e.g. the tin soldier melted)
 - tin soldier -> F (e.g. the tin soldier chuckled)
 - metal mind -> C (e.g. the computer)
 - metal theory -> C (e.g. the steam engine is theory in metal)
 - metal waiter -> C (e.g. a trolley)

- 1 Item. Animate adjective
- 2 Structure it gives in composition. Adj + Noun -> np
- 3 Categories it predicts for word it combines with. animate
- 4 Categories coerced by it. None
- 5 Categories that coerce it. Mn -> M; Bn -> B
- 6 Verbal description. An animate adjective is compatible with an animate noun but coerced by higher categories
- 7 Examples.
 - a talkative man -> A
- 8 Exceptions.
 - a talkative memory -> C (e.g. a machine)
 - a hairy idea -> A (a puppy)
 - a hairy theory -> C (e.g. velcro)

- 1 Item. Mental adjective
- 2 Structure it gives in composition. Adj + Noun -> np
- 3 Categories it predicts for word it combines with. mental or animate
- 4 Categories coerced by it. Cn -> F
- 5 Categories that coerce it. Bn -> B
- 6 Verbal description. A mental adjective is alright with an animate or mental noun. It coerces a concrete noun and is coerced by an abstract noun.
- 7 Examples.
 - contrite man -> A
 - contrite mind -> M
 - contrite bucket -> F
 - contrite theory -> B
 - contrite bucket -> A (e.g. Alf was awash with tears; he was a contrite bucket of them)
- 8 Exceptions.
 - sad bucket -> C (metaphorical usage)
 - contrite bucket -> B (dematerialised e.g. BandAid is a contrite bucket of emotions)
 - contrite bucket -> C (the dustbin outside Oxfam is a contrite bucket for money from the conscience stricken)

- 1 Item. abstract adjective
- 2 Structure it gives in composition. Adj + noun -> np
- 3 Categories it predicts for word it combines with. word
- 4 Categories coerced by it. None
- 5 Categories that coerce it. Cn -> C; An -> A; Mn -> M; Bn-> B;
- 6 Verbal description. Every noun coerces an abstract

adjective.

7 Examples.

john's hat -> C

john's mum -> A

john's theory -> B

john's memory -> M

8 Exceptions.

technological man -> C (e.g. a computer)

mathematical milestone -> B

1 Item. Animate noun

2 Structure it gives in composition. Adjective + noun -> np

3 Categories it predicts for word it combines with. word

4 Categories coerced by it. None

5 Categories that coerce it. None

6 Verbal description. An animate noun is compatible with every adjective and thus is not coerced and does not coerce any adjective.

7 Examples.

wooden man -> A

traditional man -> A

vainglorious trafficwarden -> A

sweaty newsreader -> A

8 Exceptions.

tin soldier -> C

straw man -> B

technological man -> C (e.g. a machine)

1 Item. Concrete noun

2 Structure it gives in composition. Adjective + noun -> np

3 Categories it predicts for word it combines with. concrete or abstract

4 Categories coerced by it. None.

5 Categories that coerce it. Ma -> F; Aa -> F

6 Verbal description. This combines successfully with concrete and abstract adjectives; it is coerced by a mental and animate adjectives into the figurative class.

7 Examples.

traditional bucket -> C

contrite bucket -> F

grumbling bucket -> F.

8 Exceptions. The same observations concerning ellipticality, metaphorical use and dematerialisation.

1 Item. Mental noun

2 Structure it gives in composition. Adj + noun -> np

3 Categories it predicts for word it combines with. mental or abstract

4 Categories coerced by it. Ca -> M; Aa -> M;

5 Categories that coerce it. None

6 Verbal description. This coerces concrete and animate adjectives.

7 Examples.
green mind -> M
sweaty mind -> M
traditional mind -> M
8 Exceptions. As above

1 Item. Abstract noun
2 Structure it gives in composition. Adj + noun -> np
3 Categories it predicts for word it combines with. abstract
4 Categories coerced by it. Ca -> B; Aa -> B; Ma -> B
5 Categories that coerce it. None
6 Verbal description. This coerces all the adjectives in the categories below it.
7 Examples.
metal theory -> B
grumbling theory -> B
contrite theory -> B
8 Exceptions. As above

1 Item. Concrete verb
2 Structure it gives in composition. Verb + Np2 -> vp
3 Categories it predicts for word it combines with. concrete or animate
4 Categories coerced by it. None.
5 Categories that coerce it. Mnp2 -> M; Bnp2 -> B.
6 Verbal description. This is a category true members of which are rare, for instance the neologisms like 'output' and 'autoprint'.
7 Examples.
output a bottle -> C
output a man -> C
output hostility -> M (e.g. generated an aura of being hostile)
output wealth -> B (e.g. output goods that represented wealth)
melted the soldier -> A (e.g. softened the soldier's heart)
melted the soldier -> C (e.g. melted the tin soldier)
8 Exceptions.
output a theory -> C (e.g. printed a theory on paper)

1 Item. Animate verb
2 Structure it gives in composition. Verb + np2 -> vp
3 Categories it predicts for word it combines with. concrete or animate
4 Categories coerced by it. None
5 Categories that coerce it. Fnp2 -> F; Mnp2 -> M; Bnp2 -> B
6 Verbal description. This is alright with concrete or animate np2s; any np2 in a higher category (including F because that contains one M element) coerce it.
7 Examples.
argue with the tin soldier -> F

rummage through the mind -> M
smash the theory -> B
8 Exceptions. As above

1 Item. Mental verb
2 Structure it gives in composition. Verb + np2 -> vp
3 Categories it predicts for word it combines with. word
4 Categories coerced by it. None.
5 Categories that coerce it. None
6 Verbal description. This can combine with anything.
7 Examples.
loved the dustbin -> M
loved the chiropodist -> M
loved the daydream -> M
loved the propaganda -> M
8 Exceptions. None

1 Item. Abstract verb
2 Structure it gives in composition. Verb + np2 -> vp
3 Categories it predicts for word it combines with. word
4 Categories coerced by it. None.
5 Categories that coerce it. None.
6 Verbal description. This is compatible with every object noun because it appertains to some abstract dimension of that noun.
7 Examples.
vitiated the bucket -> B (e.g. its existence)
vitiated the consultant -> B (e.g. his diagnosis)
vitiated the thought -> B (e.g. its truth)
vitiated the theory -> B
8 Exceptions. As above

1 Item. Concrete vp
2 Structure it gives in composition. Vp + np1 -> s
3 Categories it predicts for word it combines with. concrete or animate
4 Categories coerced by it. None
5 Categories that coerce it. Mnpl -> B; Bnpl -> B
6 Verbal description. This is a rare category exemplified, strictly speaking, only in, for example 'output the document', 'autoloading the disc'.
7 Examples.
the machine output the document -> C
the man output the document -> C (e.g. caused the machine to output the document);
dogged determination output that document -> M (e.g. made the man make the machine output that document);
8 Exceptions. As above.

1 Item. animate vp
2 Structure it gives in composition. Vp + np1 -> s

- 3 Categories it predicts for word it combines with. animate
- 4 Categories coerced by it. Cnpl -> F
- 5 Categories that coerce it. Mnpl -> M; Bnpl -> B
- 6 Verbal description. This is alright with animate npls;
other npls coerce or are coerced by it.
- 7 Examples.
the escalator pursued the man -> C
the janitor accosted the man -> A
the memory moved the man -> M
the verdict undermined the man -> B
- 8 Exceptions. As above

- 1 Item. Mental vp
- 2 Structure it gives in composition. Vp + npl -> s
- 3 Categories it predicts for word it combines with. animate
or mental
- 4 Categories coerced by it. Cnpl -> F
- 5 Categories that coerce it. Bnpl -> B
- 6 Verbal description. This is all right with animate or
mental npls but coerces Cnpl into its figurative dimension;
it is coerced by abstract npls.
- 7 Examples.
the bucket knew the ... -> F
the man knew the.. -> M
his reason knew the ... -> M
the theory knew the ... -> B
- 8 Exceptions. As above

- 1 Item. Abstract vp
- 2 Structure it gives in composition. Vp + npl -> s
- 3 Categories it predicts for word it combines with. word
- 4 Categories coerced by it. None.
- 5 Categories that coerce it. None
- 6 Verbal description. This is compatible with every category
in its abstract dimension.
- 7 Examples.
the bucket vitiated ...-> B (e.g. its existence vitiated...)
the man vitiated ...-> B (e.g. his presence vitiated...)
the memory justified ...-> B (e.g. its occurrence
justified...)
the ubiquity of the bastinado justified... -> B
- 8 Exceptions. As above

- 1 Item. Concrete adverb
- 2 Structure it gives in composition. Adv + s -> s
- 3 Categories it predicts for word it combines with. concrete
or animate
- 4 Categories coerced by it. None
- 5 Categories that coerce it. Ms-> M; Bs -> B
- 6 Verbal description. This is coerced by mental and abstract
sentence but is compatible with animate and concrete ones..

7 Examples.

Alf thought of Beat mechanically -> M
the lemma undermined the theory mechanically -> B
Stan coughed noisily -> A
the tea-urn clattered noisily -> C

8 Exceptions. As above.

1 Item. Animate adverb.

2 Structure it gives in composition. Adv + s -> s

3 Categories it predicts for word it combines with. animate
and concrete

4 Categories coerced by it. None.

5 Categories that coerce it. Ms -> M; Bs -> B

6 Verbal description. This is coerced by abstract and mental
sentences but is compatible with animate and concrete
sentences; the apparent coercion of a mental sentence by
an animate adverb is elliptical.

7 Examples.

Alf thought sweatily -> M
the lemma vitiated the argument sweatily -> B
the rocks glistened sweatily -> C
Stan embraced Glad sweatily -> A

8 Exceptions.

Humph thought sweatily -> A (e.g. ...thought, coming out in
sweat...)

1 Item. Abstract adverb.

2 Structure it gives in composition. Adv + s -> s

3 Categories it predicts for word it combines with. Word.

4 Categories coerced by it. None.

5 Categories that coerce it. None.

6 Verbal description. The abstract adverb is compatible with
every category.

7 Examples.

the water flooded the oubliette thoroughly -> C
Alf dried the puppy thoroughly -> A
Tim resented the archdeacon thoroughly -> M
the evidence disproved the hypothesis thoroughly -> B

8 Exceptions. None

Appendix 2. The program.

The following text is that of a small Prolog program to demonstrate the Principles of Prediction and Coercion as outlined in Chapters 6 and 7. The program incorporates a sample lexicon and a simple grammar adapted from a dialogue program written by Pereira and Shieber (Pereira and Shieber 1987) which handles nouns, adjectives and transitive verbs.

```

/* ***** */
/* Operator precedences. */

:-op(900,fx,[not]).
:-op(700,xfx,[==,=,\==,\=,is,:=,=..,==,=:,>]).
:-op(500,fx,[(-)]).

/* ***** */
/* Not */

not X :-
    X,
    !,
    fail.

not X.

/* ***** */
/*
*/

:- nl,
    write('Type hello. to begin please. '),
    nl.

/* ***** */
/* isclass(X) where X is a non-leaf in the dictionary tree*/

isclass(top).

isclass(X) :-
    hasdescendant(Y,X),
    isclass(Y).

/* ***** */
/* isontoclass(X) where X is an ontological class */

isontoclass(abstract).
isontoclass(mental).
isontoclass(animate).
isontoclass(concrete).

/* ***** */
/* hasdescendant(Y,X) where Y is a class that has a */
/* subclass X */

hasdescendant(Y,X) :-
    subsumes(Y,X).

hasdescendant(Y,X) :-
    subsumes(Z,X),
    hasdescendant(Y,Z).

/* ***** */
/* subsumes(X,Y) where X is the superordinate class of Y */
/* and X and Y can be object language or meta language */
/* words */

```

```

subsumes(partofspeech, adjective) .
subsumes(partofspeech, noun) .
subsumes(partofspeech, transitive_verb) .
subsumes(partofspeech, noun1) .
subsumes(partofspeech, noun2) .
subsumes(partofspeech, adjective1) .
subsumes(partofspeech, adjective2) .

subsumes(transitive_verb, concrete_transitive_verb) .
subsumes(transitive_verb, animate_transitive_verb) .
subsumes(transitive_verb, mental_transitive_verb) .
subsumes(transitive_verb, abstract_transitive_verb) .

subsumes(adjective1, concrete_adjective) .
subsumes(adjective1, animate_adjective) .
subsumes(adjective1, mental_adjective) .
subsumes(adjective1, abstract_adjective) .

subsumes(adjective2, concrete_adjective) .
subsumes(adjective2, animate_adjective) .
subsumes(adjective2, mental_adjective) .
subsumes(adjective2, abstract_adjective) .

subsumes(noun1, concrete_noun) .
subsumes(noun1, animate_noun) .
subsumes(noun1, mental_noun) .
subsumes(noun1, abstract_noun) .

subsumes(noun2, concrete_noun) .
subsumes(noun2, animate_noun) .
subsumes(noun2, mental_noun) .
subsumes(noun2, abstract_noun) .

subsumes(concrete_noun, bucket) .
subsumes(animate_noun, man) .
subsumes(abstract_noun, theory) .
subsumes(mental_noun, mind) .

subsumes(concrete_adjective, red) .
subsumes(animate_adjective, forlorn) .
subsumes(concrete_adjective, metal) .
subsumes(abstract_adjective, french) .
subsumes(mental_adjective, contrite) .

subsumes(animate_transitive_verb, avoids) .
subsumes(concrete_transitive_verb, outputs) .
subsumes(abstract_transitive_verb, vitiates) .
subsumes(mental_transitive_verb, despises) .

subsumes(top, concrete) .
subsumes(top, animate) .
subsumes(top, mental) .
subsumes(top, abstract) .
subsumes(top, partofspeech) .

subsumes(concrete, concrete_noun) .
subsumes(concrete, concrete_transitive_verb) .

```

```

subsumes (concrete, concrete_adjective) .

subsumes (animate, animate_noun) .
subsumes (animate, animate_transitive_verb) .
subsumes (animate, animate_adjective) .

subsumes (mental, mental_noun) .
subsumes (mental, mental_transitive_verb) .
subsumes (mental, mental_adjective) .

subsumes (abstract, abstract_noun) .
subsumes (abstract, abstract_transitive_verb) .
subsumes (abstract, abstract_adjective) .

subsumes (abstract_noun, happiness) .

subsumes (man, scotsman) .

/* ***** */
/* predicts (W,X,Y,Z) where part of speech X of class */
/* W predicts class Y for part of speech Z */

predicts (animate, [vp], [animate], [noun1, np1]) .
predicts (concrete, [vp], [concrete, animate], [noun1, np1]) .
predicts (mental, [vp], [mental, animate], [noun1, np1]) .
predicts (abstract, [vp], [concrete, animate, mental, abstract],
[noun1, np1]) .

predicts (concrete, [noun1, np1], [abstract, concrete], [vp]) .
predicts (mental, [noun1, np1], [abstract, mental], [vp]) .
predicts (abstract, [noun1, np1], [abstract], [vp]) .
predicts (figurative, [noun1, np1], [concrete, animate, mental, abstract], [vp]) .
predicts (animate, [noun1, np1], [concrete, animate, mental, abstract], [vp]) .

predicts (animate, [adjective1], [animate], [noun1]) .
predicts (concrete, [adjective1], [concrete, animate], [noun1]) .
predicts (mental, [adjective1], [mental, animate], [noun1]) .
predicts (abstract, [adjective1], [concrete, animate, mental,
abstract], [noun1]) .

predicts (concrete, [noun1], [concrete, abstract], [adjective1]) .
predicts (mental, [noun1], [mental, abstract], [adjective1]) .
predicts (abstract, [noun1], [abstract], [adjective1]) .
predicts (figurative, [noun1], [concrete, animate,
mental, abstract], [adjective1]) .
predicts (animate, [noun1], [concrete, animate,
mental, abstract], [adjective1]) .

predicts (animate, [adjective2], [animate], [noun2]) .
predicts (concrete, [adjective2], [concrete, animate], [noun2]) .
predicts (mental, [adjective2], [mental, animate], [noun2]) .
predicts (abstract, [adjective2], [concrete, animate, mental,
abstract], [noun2]) .

predicts (concrete, [noun2], [concrete, abstract], [adjective2]) .
predicts (mental, [noun2], [mental, abstract], [adjective2]) .
predicts (abstract, [noun2], [abstract], [adjective2]) .

```

```

predicts(figurative,[noun2],[concrete,animate,mental,abstract],[adjective2]).
predicts(animate,[noun2],[concrete,animate,
    mental,abstract],[adjective2]).

predicts(animate,[transitive_verb],[animate,concrete],[noun2,np2]).
predicts(concrete,[transitive_verb],[animate,concrete],[noun2,np2]).
predicts(mental,[transitive_verb],[concrete,animate,
    mental,abstract],[noun2,np2]).
predicts(abstract,[transitive_verb],[concrete,animate,
    mental,abstract],[noun2,np2]).

predicts(concrete,[noun2,np2],[concrete,animate,mental,
    abstract],[transitive_verb]).
predicts(mental,[noun2,np2],[mental,abstract],[transitive_verb]).
predicts(abstract,[noun2,np2],[mental,abstract],[transitive_verb]).
predicts(figurative,[noun2,np2],[concrete,animate,mental,
    abstract],[transitive_verb]).
predicts(animate,[noun2,np2],[concrete,animate,mental,
    abstract],[transitive_verb]).

predicts(concrete,[noun1,np1],[concrete,abstract],[noun2,np2]).
predicts(animate,[noun1,np1],[concrete,animate,abstract],
    [noun2,np2]).
predicts(mental,[noun1,np1],[mental,abstract],[noun2,np2]).
predicts(abstract,[noun1,np1],[abstract],[noun2,np2]).

predicts(concrete,[noun2,np2],[animate,concrete],[noun1,np1]).
predicts(animate,[noun2,np2],[animate],[noun1,np1]).
predicts(mental,[noun2,np2],[mental_noun],[noun1,np1]).
predicts(abstract,[noun2,np2],[concrete,animate,mental,
    abstract],[noun1,np1]).

/* ***** */
/* coercedclass(X,Y,Z) where conflicting classes X */
/* and Y are resolved as class Z */

coercedclass(concrete,animate,animate).
coercedclass(concrete,mental,mental).
coercedclass(concrete,abstract,abstract).
coercedclass(animate,concrete,animate).
coercedclass(animate,mental,mental).
coercedclass(animate,abstract,abstract).
coercedclass(mental,concrete,mental).
coercedclass(mental,animate,mental).
coercedclass(mental,abstract,abstract).
coercedclass(abstract,concrete,abstract).
coercedclass(abstract,mental,abstract).
coercedclass(abstract,animate,abstract).

/* ***** */
/* combinedpos(X,Y,Z) where part of speech X and */
/* part of speech Y combine to form part of speech Z*/

combinedpos(noun,adjective,np1).
combinedpos(adjective,noun,np1).
combinedpos(transitive_verb,np2,vp).
combinedpos(np2,transitive_verb,vp).

```



```

/* ***** */
/* semantics(X,Y) */
/* If input is 'X subsumes Y' or 'X is a Y' assert */
/* subsumption in the database. */

semantics((F0 :- G0) :- H0),Pospeechlist):-
    functor(F0,'subsumes',2),
    functor(Ass,'subsumes',2),
    functor(H0,Arg1,_),
    arg(1,Ass,Arg1),
    functor(G0,Arg2,_),
    arg(2,Ass,Arg2),
    assertsubsumption(Ass).

/* ***** */

semantics((F0 :- G0),Pospeechlist):-
    functor(F0,F,1),
    functor(G0,G,1),
    arg(1,F0,Farg),
    arg(1,G0,Garg),
    var(Farg),
    var(Garg),
    member('copi',Pospeechlist),
    askwhethersubsume(F,G),
    numberitem(noun,Pospeechlist,Pospeechlist2,noun1),
    numberitem(noun,Pospeechlist2,Pospeechlist3,noun2),
    testforadj(Pospeechlist3,Pospeechlist4),
    numberitem(adjective,Pospeechlist4,Pospeechlist5,adjective2),
    semax((F0 :- G0),Pospeechlist5).

/* ***** */

semantics(X,Pospeechlist):-
    numberitem(noun,Pospeechlist,Pospeechlist2,noun1),
    numberitem(noun,Pospeechlist2,Pospeechlist3,noun2),
    testforadj(Pospeechlist3,Pospeechlist4),
    numberitem(adjective,Pospeechlist4,Pospeechlist5,adjective2),
    semax(X,Pospeechlist5).

/* ***** */
/* testforadj(X,Y) */

testforadj(Pin,Pout):-
    nextto(adjective,Aword,Pin),
    nextto(Aword,noun1,Pin),
    numberitem(adjective,Pin,Pout,adjective1).

testforadj(Pin,Pin).

/* ***** */
/* semax(X,Y) where X is logical form and Y is the */
/* input sentence and its parts of speech */
/* Gets unknown adjective1 */
/* Looks for known noun1 */

semax(Assertion,Pospeechlist):-

```

```

getu(Assertion,Unkclause,adjective1,1,Unkword,Unkvar1,Unkvar2,Pospeechlist),
getk(Assertion,Unkvar1,1,Kfun,noun1,Kclass,Kclause,Pospeechlist),
getpredictor(Kclass,noun1,adjective1,Unkword).

/* ***** */
/* semax(X,Y) */
/* Gets unknown noun1 */
/* Looks for known noun2 */
/* e.g. every man is a priest */

semax(Assertion,Pospeechlist):-
getu(Assertion,Unkclause,noun1,1,Unkword,Unkvar1,Unkvar2,Pospeechlist),
getk(Assertion,Unkvar1,1,Kfun,noun2,Kclass,Kclause,Pospeechlist),
getpredictor(Kclass,noun2,noun1,Unkword).

/* ***** */
/* semax(X,Y) */
/* Gets unknown adjective2 */
/* Looks for known noun2 */

semax(Assertion,Pospeechlist):-
getu(Assertion,Unkclause,adjective2,1,Unkword,Unkvar1,Unkvar2,Pospeechlist),
getk(Assertion,Unkvar1,1,Kfun,noun2,Kclass,Kclause,Pospeechlist),
getpredictor(Kclass,noun2,adjective2,Unkword).

/* ***** */
/* semax(X,Y) */
/* Gets unknown noun1 */
/* Looks for known adjective1 */

semax(Assertion,Pospeechlist):-
getu(Assertion,Unkclause,noun1,1,Unkword,Unkvar1,Unkvar2,Pospeechlist),
getk(Assertion,Unkvar1,1,Kfun,adjective1,Kclass,Kclause,Pospeechlist),
getpredictor(Kclass,adjective1,noun1,Unkword).

/* ***** */
/* semax(X,Y) */
/* Gets unknown noun2 */
/* Looks for known adjective2 */

semax(Assertion,Pospeechlist):-
getu(Assertion,Unkclause,noun2,1,Unkword,Unkvar1,Unkvar2,Pospeechlist),
getk(Assertion,Unkvar1,1,Kfun,adjective2,Kclass,Kclause,Pospeechlist),
getpredictor(Kclass,adjective2,noun2,Unkword).

/* ***** */
/* semax(X,Y) */
/* Gets unknown noun2 */
/* Looks for known transitive_verb */

semax(Assertion,Pospeechlist):-
getu(Assertion,Unkclause,noun2,1,Unkword,Unkvar1,Unkvar2,Pospeechlist),
getk(Assertion,Unkvar1,2,Kfun,transitive_verb,Kclass,Kclause,Pospeechlist),
getpredictor(Kclass,transitive_verb,noun2,Unkword).

/* ***** */
/* semax(X,Y) */

```

```

/* Gets unknown transitive_verb          */
/* Looks for known noun2                  */
/* Looks for known adjective2             */

semax (Assertion, Pospeechlist) :-
    getu (Assertion, Unkclause, transitive_verb, 2, Unkword, Unkvar1, Unkvar2,
          Pospeechlist),
    nextto (Unkword, Upos, Pospeechlist),
    getk (Assertion, Unkvar2, 1, Kfun, noun2, Kclass, Kclause, Pospeechlist),
    getk (Assertion, Unkvar2, 1, Kfun2, adjective2, Kclass2, Kclause2, Pospeechlist),
    getcombinedclass (Kclass, noun2, Kclass2, adjective2, Combpos, Combclass,
                      Upos, Unkword),
    getpredictor (Combclass, np2, transitive_verb, Unkword) .

/* ***** */
/* semax (X, Y) */
/* Gets unknown transitive_verb */
/* Looks for known noun2 */
/* No known adjective2 */

semax (Assertion, Pospeechlist) :-
    getu (Assertion, Unkclause, transitive_verb, 2, Unkword, Unkvar1, Unkvar2,
          Pospeechlist),
    getk (Assertion, Unkvar2, 1, Kfun, noun2, Kclass, Kclause, Pospeechlist),
    getpredictor (Kclass, noun2, transitive_verb, Unkword) .

/* ***** */
/* semax (X, Y) */
/* Gets unknown noun1 and there is no adjective1 */
/* Looks for known transitive_verb */

semax (Assertion, Pospeechlist) :-
    getu (Assertion, Unkclause, noun1, 1, Unkword, Unkvar1, Unkvar2, Pospeechlist),
    nextto (Unkword, Upos, Pospeechlist),
    getk (Assertion, Unkvar1, 1, Kfun, transitive_verb, Kclass, Kclause, Pospeechlist),
    arg (2, Kclause, Kvar2),
    getk (Assertion, Kvar2, 1, K2fun, noun2, K2class, K2clause, Pospeechlist),
    getk (Assertion, Kvar2, 1, K3fun, adjective2, K3class, K3clause, Pospeechlist),
    getcombinedclass (K2class, noun2, K3class, adjective2, Combpos, Combclass,
                      Upos, Unkword),
    getcombinedclass (Combclass, Combpos, Kclass, transitive_verb, Ultpos, Ultclass,
                      Upos, Unkword),
    getpredictor (Ultclass, Ultpos, noun1, Unkword) .

/* ***** */
/* semax (X, Y) */
/* Gets unknown noun1 and there is no adjective1 */
/* Looks for known transitive_verb. There is a known */
/* noun2 but no known adjective2. */

semax (Assertion, Pospeechlist) :-
    getu (Assertion, Unkclause, noun1, 1, Unkword, Unkvar1, Unkvar2, Pospeechlist),
    nextto (Unkword, Upos, Pospeechlist),
    getk (Assertion, Unkvar1, 1, Kfun, transitive_verb, Kclass, Kclause, Pospeechlist),
    arg (2, Kclause, Kvar2),
    getk (Assertion, Kvar2, 1, K2fun, noun2, K2class, K2clause, Pospeechlist),
    getcombinedclass (K2class, noun2, Kclass, transitive_verb, Combpos, Combclass,

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```

                                Upos, Unkword) ,
    getpredictor(Combclass, Combpos, noun1, Unkword) .

/* ***** */
/* semax(X,Y) */
/* Gets unknown transitive_verb */
/* Gets known noun2 */
/* No known adjective2 */

semax(Assertion, Pospeechlist):-
    getu(Assertion, Unkclause, transitive_verb, 2, Unkword, Unkvar1, Unkvar2,
        Pospeechlist),
    getk(Assertion, Unkvar2, 1, Kfun, noun2, Kclass, Pospeechlist),
    getpredictor(Kclass, noun2, transitive_verb, Unkword) .

/* ***** */
/* semax(X,Y) */
/* Gets unknown noun1 */
/* Gets known transitive_verb */
/* No known noun2 */

semax(Assertion, Pospeechlist):-
    getu(Assertion, Unkclause, noun1, 1, Unkword, Unkvar1, Unkvar2, Pospeechlist),
    getk(Assertion, Unkvar1, 1, Kfun, transitive_verb, Kclass, Pospeechlist),
    getpredictor(Kclass, transitive_verb, noun1, Unkword) .

/* ***** */
/* semax(X,Y) */
/* Gets unknown noun2 */
/* Looks for known noun1 */
/* e.g. every scotsman is a man */

semax(Assertion, Pospeechlist):-
    getu(Assertion, Unkclause, noun2, 1, Unkword, Unkvar1, Unkvar2, Pospeechlist),
    getk(Assertion, Unkvar1, 1, Kfun, noun1, Kclass, Kclause, Pospeechlist),
    getpredictor(Kclass, noun1, noun2, Unkword) .

/* ***** */
/* semax(X,Y) */
/* All previous tests failed */
/* Get unknown word and its p.o.s. and subclasses */
/* of its p.o.s. and ask which of latter should */
/* subsume unknown functor */

semax(Assertion, Pospeechlist):-
    getu(Assertion, Unkclause, Anypos, 1, Unkword, Unkvar1, Unkvar2, Pospeechlist),
    askaboutunknown(Unkclause, Anypos) .

/* ***** */
/* semax(X,Y) */
/* No unknowns */
/* Looks for known functor; gets its subclasses */
/* and ask user to refine former into one of latter*/

semax(Assertion, Pospeechlist):-
    getanyk(Assertion, Kfun),
    getsubclassesandaskforrefine(Kfun) .

```

```

/* ***** */
/* semax(X,Y) */
/* All previous tests failed. */

semax(Assertion,Pospeechlist):-
    nl,
    write(' No semantic analysis. ').

/* ***** */
/* numberitem(Oldword,Oldlist,Newlist,Newword) */
/* Numbers parts of speech in the p.o.s. list */

numberitem(X, [X|Xs], [W|Xs], W) .

numberitem(X, [Y|Ys], [Y|Zs], W):-
    X \== Y,
    numberitem(X, Ys, Zs, W) .

numberitem(X, [A|B], [A|B], W) .

/* ***** */
/* getpredictor(W,X,Y,Z) */
/* Gets predicted class for unknown word */

getpredictor(Kclass, Kpos, Upos, Unkword):-
    predicts(Kclass, Klist, Predictedclass, Ulist),
    member(Kpos, Klist),
    member(Upos, Ulist),
    askwhichsubclass(Unkword, Predictedclass) .

/* ***** */
/* getcombinedclass(A,B,C,D,E,F,G,H) */
/* Gets class of linguistic phrase from the class of */
/* its parts */

getcombinedclass(Kclass, Kpos, K2class, K2pos, Combpos, Combclass, Upos, Unkword):-
    predicts(Kclass, Kposlist, Predictedclass, K2poslist),
    member(K2pos, K2poslist),
    member(Kpos, Kposlist),
    member(K2class, Predictedclass),
    combinedclass(Kpos, Kclass, K2pos, K2class, Combpos, Head, Upos),
    same(Kpos, Head, Combclass, Kclass) .

/* getcombinedclass(A,B,C,D,E,F,G,H) */

getcombinedclass(Kclass, Kpos, K2class, K2pos, Combpos, Combclass, Upos, Unkword):-
    predicts(Kclass, Kposlist, Predictedclass, K2poslist),
    member(Kpos, Kposlist),
    member(K2class, Predictedclass),
    member(K2pos, K2poslist),
    combinedclass(Kpos, Kclass, K2pos, K2class, Combpos, Head, Upos),
    same(K2pos, Head, Combclass, K2class) .

/* ***** */

getcombinedclass(Kclass, Kpos, K2class, K2pos, Combpos, Combclass, Upos, Unkword):-
    coercedclass(Kclass, K2class, Combclass),

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combinedpos (Kpos, K2pos, Combpos) .

/* ***** */
/* getontoclass (X, Y) */
/* Gets the lowest available ontological */
/* class of a word. */

getontoclass (Keyfun, X) :-
    hasdescendant (X, Keyfun) ,
    isontoclass (X) ,
    not (hasdescendant (X, Y)) ,
    isontoclass (Y) .

/* ***** */
/* nextto (X, Y, Z) */
/* Finds word in a list next to input word. */

nextto (X, Y, [X, Y|_]) .
nextto (X, Y, [_|Z]) :-
    nextto (X, Y, Z) .

/* ***** */
/* getu (A, B, C, D, E, F, G, H) */
/* Gets an unknown lpp clause */
/* out of an assertion. */

getu (Ass, Unkcl, Possought, 1, Unkword, Unkvar1, Unkvar2, Pospeechlist) :-
    subterm (Unkcl, Ass) ,
    nonvar (Unkcl) ,
    functor (Unkcl, Unkword, 1) ,
    arg (1, Unkcl, Unkvar1) ,
    nextto (Unkword, Possought, Pospeechlist) ,
    notclass (Unkword) .

/* Gets an unknown 2pp clause */
/* out of an assertion. */

getu (Ass, Unkcl, Possought, 2, Unkword, Unkvar1, Unkvar2, Pospeechlist) :-
    subterm (Unkcl, Ass) ,
    nonvar (Unkcl) ,
    functor (Unkcl, Unkword, 2) ,
    arg (1, Unkcl, Unkvar1) ,
    arg (2, Unkcl, Unkvar2) ,
    nextto (Unkword, Possought, Pospeechlist) ,
    notclass (Unkword) .

/* ***** */
/* getk (A, B, C, D, E, F, G, H) */
/* Get a known clause of p.o.s. Kpos with */
/* argument Unkvar shared by unknown word */

getk (Ass, Unkvar, Oneortwo, Kfun, Kpos, Kclass, Kclause, Pospeechlist) :-
    subterm (Kclause, Ass) ,
    nonvar (Kclause) ,
    arg (Oneortwo, Kclause, Kvar) ,
    Unkvar == Kvar ,
    functor (Kclause, Kfun, _) ,

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```

nextto(Kfun,Kpos,Pospeechlist),
hasdescendant(Kclass,Kfun),
isontoclass(Kclass).

/* ***** */
/* getanyk(X,Y) */
/* Get any known clause */

getanyk(Ass,Kfun):-
    subterm(Kclause,Ass),
    nonvar(Kclause),
    functor(Kclause,Kfun,_),
    hasdescendant(Kclass,Kfun),
    isontoclass(Kclass).

/* ***** */
/* combinedclass(A,B,C,D,E,F) */
/* Gets class of linguistic phrase from class of its */
/* parts */

combinedclass(Kpos,Kclass,K2pos,K2class,Combpos,Head,Upos):-
    predicts(Kclass,Kposlist,Predictedclass,K2poslist),
    member(Kpos,Kposlist),
    member(K2pos,K2poslist),
    member(K2class,Predictedclass),
    combinedpos(Kpos,K2pos,Combpos,Head,Upos).

/* ***** */
/* same(A,A,B,B) */

same(A,A,B,B).

/* ***** */
/* combinedpos(A,B,C,D) */
/* Gets p.o.s. of a linguistic phrase from p.o.s's of */
/* its parts */

combinedpos(transitive_verb,np2,vp,transitive_verb,_).
combinedpos(adjective2,noun2,np2,noun2,transitive_verb).
combinedpos(np2,transitive_verb,vp,transitive_verb,_).
combinedpos(noun2,transitive_verb,vp,transitive_verb,_).
combinedpos(noun2,adjective2,np2,noun2,transitive_verb).
combinedpos(adjective1,noun1,np1,noun1,vp).
combinedpos(noun1,adjective1,np1,noun1,vp).

/* ***** */
/* isknown(X) */
/* Checks a functor for presence in the */
/* subsumption lattice. */

isknown(Kfun):-
    subsumes(Anything,Kfun).

/* ***** */
/* subterm(X,Y) */
/* Gets a subterm from the logical form. */
/* e.g. subterm(S,(snores(X):-man(X))). */

```



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subterm(Sub, Term) :-
    nonvar(Term),
    functor(Term, F, N),
    subterm(N, Sub, Term).

subterm(N, Sub, Term) :-
    N > 1,
    N1 is N-1,
    subterm(N1, Sub, Term).

subterm(N, Sub, Term) :-
    arg(N, Term, Arg),
    subterm(Sub, Arg).

subterm(Term, Term).

/* ***** */
/* notclass(X) */
/* Tests for unknown functor: unknown if */
/* not a class. */

notclass(Unkfun) :-
    not(isclass(Unkfun)).

/* ***** */
/* askaboutunknown(X,Y) */
/* Get subclasses of part of speech of */
/* unknown functor and ask which latter */
/* belongs to. */

askaboutunknown(Clause, Posp) :-
    member(Posp, [transitive_verb, noun,
        adjective, noun1, noun2, adjective1, adjective2]),
    functor(Clause, Clausefun, Arity),
    Arity = 1,
    getsubclassesandaskwhich(Posp, Clausefun).

askaboutunknown(Clause, Posp) :-
    functor(Clause, Clausefun, Arity),
    getsubclassesandaskwhich(other_predicate, Clausefun).

/* ***** */
/* ironootcls(X,Y) */
/* Routine to remove brackets */

ironootcls(X, Y) :-
    ironoot(X, Y),
    !.

/* ***** */
/* ironoot(X,Y) */
/* e.g. ironoot([[[[a], b], c], d], X). */
/* X = [a, b, c, d]. */

ironoot([H|T], Y) :- ironoot(H, W),
                    ironoot(T, X),
                    conc(W, X, Y).

```



```

ironoot([], []).
ironoot(X, [X]).

/* ***** */
/* lexttranslatecls(X,Y) */
/* This scans the input string and makes a list */
/* of the known p.o.s's it contains */

lexttranslatecls(X,Y):-
    lexttranslate(X,Y),
    !.

/* ***** */
/* lexttranslate(X,Y) */
/* e.g. lexttranslate([bucket],L). */
/* L = [noun] */

lexttranslate([Word|Words], [Pospeech|Pospeechs]):-
    lexttype(Word, Pospeech),
    lexttranslate(Words, Pospeechs),
    lexttranslate([], []).

/* ***** */
/* member(X,Y) where X is a member of Y */

member(X, [X|Xs]).

member(X, [Y|Ys]):-
    member(X, Ys).

/* ***** */
/* lexttype(X,Y) */
/* Gets part of speech of known word */

lexttype(Word, Pospeech):-
    hasdescendant(Pospeech, Word),
    hasdescendant(part_of_speech, Pospeech).

lexttype(Word, X).

/* ***** */
/* Parts of the grammar following are amended */
/* from Pereira and Shieber's dialogue program. */
/* See Prolog and Natural Language */
/* Analysis. Pereira FCN and Shieber SM CLSI 1987 */
/* p 212. */

/* ***** */
/* Operator precedences. */

:- op(500,xfy,&).
:- op(510,xfy,=>).
:- op(1,fx,').

/* ***** */
/* hello */
/* Prompt, accept input, parse and reply. */

```

```

hello:-
    main_loop.

/* ***** */

main_loop :-
    write('>> '),
    read_sent(Words),
    talk(Words, Reply),
    print_reply(Reply),
    main_loop.

/* ***** */
/* talk(Sentence, Reply). */
/* This parses the user's input sentence to FOL */
/* and FOL to Horn clause if poss, and replies */
/* appropriately. */
/* Take sentence; get its list of p.o.s.'s; parse */
/* it; get its list of parse p.o.s.'s; remove */
/* brackets from latter; match p.o.s. list and */
/* parse p.o.s. list; merge sentence with parse pos */
/* list; remove brackets; clausify the lf from the */
/* parse; reply with the lf. */
/* e.g. talk([every,dog,likes,bones],P). */

talk(Sentence, Reply) :-
    lexttranslatecls(Sentence, Skeleton),
    nl,
    parse(Sentence, LF, Type, Brackskeleton),
    ironootcls(Brackskeleton, Unbrackskeleton),
    Unbrackskeleton = Skeleton,
    merge(Sentence, Unbrackskeleton, Pospeechlistbra),
    ironoot(Pospeechlistbra, Pospeechlist),
    tidyverbs(Pospeechlist, Pospeechlist2),
    clausify(LF, Clause, FreeVars),
    !,
    reply(Type, FreeVars, Clause, Reply, Pospeechlist2).

talk(_Sentence, error(' Please go on.')).

/* ***** */
/* tidyverbs(Pospeechlist,X) */
/* Find present tense of input verb */

tidyverbs(Pospeechlist, Pospeechlist2) :-
    member(Tensedverb, Pospeechlist),
    tv(Tensedverb, Logverb, C, D, E, F),
    numberitem(Tensedverb, Pospeechlist, Pospeechlist2, Logverb).

tidyverbs(Pospeechlist, Pospeechlist).

/* ***** */
/* merge(X,Y,Z) */
/* e.g. merge([dulce,decorum],[et,est],L). */
/* L = [dulce,et,[decorum,est,[]]] */

merge([X|Xs],[Y|Ys],[X,Y,Zs]) :-

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merge(Xs, Ys, Zs) .

merge([], [X|Xs], [X|Xs]) .

merge(Xs, [], Xs) .

/* ***** */
/* reply(Inputtype, Freevars, Hornclause, Hornclause, Reply) . */
/* Inputtype is assertion. */
/* Freevars are the free variables (to be interpreted */
/* existentially) in the clause. */
/* Assert assertion to the database. Do semantic */
/* analysis of unknowns in lf. */

reply(assertion, FreeVars, Assertion, asserted(Assertion),
      Pospeechlist) :-
    assert(Assertion),
    nl,
    semantics(Assertion, Pospeechlist),
    !.

reply(_Type, _FreeVars, _Clause, error('Please go ahead.'),
      Pospeechlist).

/* ***** */
/* print_reply(Reply) . */
/* This outputs the reply generated by the last predicate */
/* in a tidy form. */

print_reply(error(ErrorType)) :-
    write(ErrorType),
    write('.'),
    nl,
    nl.

print_reply(asserted(Assertion)) :-
    nl,
    write('Asserted: '),
    write(Assertion),
    nl,
    nl.

print_reply(answer(Answers)) :-
    print_answers(Answers).

/* ***** */
/* print_answers(Answers) . */
/* This loops through the poss. answers outputting */
/* them in a tidy form. */

print_answers([Answer]) :-
    !,
    write(Answer),
    write('.'),
    nl.

print_answers([Answer|Rest]) :-

```

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write(Answer),
write(' ', ' '),
print_reply(answer(Rest)).

/* ***** */
/* parse(Sentence, LF, Type). */
/* Type is assertion. LF and Type are both */
/* outputs. */
/* The first clause parses an assertion: a finite */
/* sentence without gaps. */
/* e.g. parse([every,dog,likes,bones],M,K,L). */

parse(Sentence, LF, assertion, Skeleton) :-
    s(LF, nogap, Skeleton, Sentence, []).

/* ***** */
/* clausify(FOL, Clause, Freevars). */
/* Clause and Freevars are both outputs. */

clausify(all(X,F0),F,[X|V]) :-
    clausify(F0,F,V).

clausify(A0=>C0,(C:-A),V) :-
    clausify(C0,C,V0),
    clausify(A0,A,V).

clausify(E0&F0,(E,F),V) :-
    clausify(E0,E,V0),
    clausify(F0,F,V1),
    conc(V0,V1,V).

clausify(exists(X,F0),exists(X,F0),V).

clausify(C0,C,V) :-
    clausify_literal(C0,C).

/* ***** */
/* clausify_literal(X,Y) */

clausify_literal('L,L').

/* ***** */
/* Grammar. */
/* Typical order of and vals for args: */
/* (Verbform, FOLlogicalform, Gapinfo) where */
/* verb form is e.g. finite,nonfinite etc (for main verbs) */
/* gap info is nogap or */
/* gap(Nonterm, Var) where */
/* Nonterm is nonterminal for gap */
/* Var is the LF variable the filler will bind. */

/* ***** */
/* S clauses ie declarative sentences */
/* e.g. */
/* s(M,N,B,[every,dog,likes,bones],L). */

s(S, GapInfo, [[_|_|Pos1|Pos2]]) -->

```

```

np(VP^S, nogap, Pos1),
vp(finite, VP, GapInfo, Pos2).

s(S, GapInfo, [[]|Pos1|Pos2]) -->
  np(VP^S, nogap, Pos1),
  vp(X, VP, GapInfo, Pos2).

/* ***** */
/* NP clauses */

np(NP, nogap, [det|[Posa|[Posb|Posc]]]) -->
  det(N4^NP, det),
  ap(N2, Posa),
  optnprepp(N2^N3, Posb),
  optrel(N3^N4, Posc).

np((X^S1)^all(X, (S2=>S1)), nogap, Pos1) -->
  detlessnoptrel(X^S2, Pos1).

np((X^S)^S, gap(np, X), []) --> [].

npisamare(NP, nogap, [det|[Posa|[Posb|Posc]]]) -->
  detisamare(N4^NP, det),
  ap(N2, Posa),
  optnprepp(N2^N3, Posb),
  optrel(N3^N4, Posc).

npisamare((X^S)^S, gap(np, X), []) --> [].

/* ***** */
/* DETLESS clauses */

detlessnoptrel(DLNO, [Pos1|[Pos2|Pos3]]) -->
  ap(N0, Pos1),
  optnprepp(N0^N1, Pos2),
  optrel(N1^DLNO, Pos3).

/* ***** */
/* VP clauses */

/* is a man */

vp(finite, X^S, GapInfo, [copi|Pos2]) -->
  copisamare(copi),
  npisamare((X^P)^exists(X, S&P), GapInfo, Pos2).

/* is good food */
/* is a good man */

vp(finite, X^S, GapInfo, [copi|Pos2]) -->
  copisamare(copi),
  np((X^S1)^all(X, (S=>S1)), GapInfo, Pos2).

/* likes a woman */

vp(Form, X^S, GapInfo, [transitive_verb|Pos2]) -->

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    tv(Form, X^VP, transitive_verb),
    np(VP^S, GapInfo, Pos2).

/* likes a good woman */
/* likes good women */

vp(Form, X^S, GapInfo, [transitive_verb|Pos2]) -->
    tv(Form, X^VP, transitive_verb),
    ap(VP^S, GapInfo, Pos2).

/* ***** */
/* AP clauses */

adjp(A^A, []) --> [].

/* e.g. old */

adjp((X^S1)^(X^(S1&S2)), adjective) -->
    adj(X^S2, adjective).

/* e.g. happy man */

ap(N3, [Pos1|noun]) -->
    adjp(N2^N3, Pos1),
    n(N2, noun).

/* ***** */
/* OPTNPREPP clauses */

optnprepp(N^N, []) --> [].

/* ***** */
/* OPTREL clauses */

optrel(N^N, []) --> [].

/* ***** */
/* PRETERMINALS. */
/* NB The verb entry arguments are: */
/* 1 nonfinite form of the verb, */
/* 2 third person singular present tense form of the */
/* verb, */
/* 3 past tense form of the verb, */
/* 4 past participle form of the verb, */
/* 5 present participle form of the verb, */
/* 6 logical form of the verb. */

adj(LF, []) --> [].
adj(LF, adjective) --> [A], {adj(A, LF)}.

copisamare(copi) --> [COP], {copisamare(COP)}.

det(LF, det) --> [D], {det(D, LF)}.
detisamare(LF, det) --> [DETIS], {detisamare(DETIS, LF)}.

n(LF, noun) --> [N], {n(N, LF)}.

```

```

relpron(rel) --> [RP], {relpron(RP)}.

tv(nonfinite,      LF,transitive_verb) --> [TV], {tv(TV, _, _, _, LF)}.
tv(finite,         LF,transitive_verb) --> [TV], {tv(  , TV, _, _, LF)}.
tv(pfinite,        LF,transitive_verb) --> [TV], {tv(  ,  , TV, _, LF)}.
tv(past_participle, LF,transitive_verb) --> [TV], {tv(  , _, _, TV, LF)}.
tv(pres_participle, LF,transitive_verb) --> [TV], {tv(  , _, _,  , TV, LF)}.

/* ***** */
/* PARSERS LEXICON */
/* Contains all the words the parser knows. */

/* A */

adj( red,          X^ 'red(X)).
adj( metal,        X^ 'metal(X)).
adj( contrite,      X^ 'contrite(X)).
adj( french,        X^ 'french(X)).

/* C */

copisamare(is).

/* D */

det( some,          (X^S1)^(X^S2)^exists(X, S1&S2)).
det( every,          (X^S1)^(X^S2)^ all(X, S1=>S2) ).
det( a,              (X^S1)^(X^S2)^exists(X, S1&S2) ).
det( an,             (X^S1)^(X^S2)^exists(X, S1&S2) ).

detisamare( every,   (X^S1)^(X^S2)^ all(X, S1=>S2) ).
detisamare( a,       (X^S1)^(X^S2)^exists(X, S1&S2)).
detisamare( an,      (X^S1)^(X^S2)^exists(X, S1&S2)).
detisamare(some,     (X^S1)^(X^S2)^exists(X, S1&S2)).

detlessn( concrete, X^ 'concrete(X)).
detlessn( animate,  X^ 'animate(X)).
detlessn( mental,   X^ 'mental(X)).
detlessn( abstract, X^ 'abstract(X)).

/* N */

n( man,            X^ 'man(X)           ).
n( bucket,         X^ 'bucket(X)        ).
n( thought,        X^ 'thought(X)       ).
n( mind,           X^ 'mind(X)          ).
n( theory,         X^ 'theory(X)        ).

/* T */

tv(follow,follows, followed,
   followed, following, X^Y^ ' follows(X,Y) ).
tv(vitiate,vitiates, vitiated,
   vitiated, vitiating, X^Y^ ' vitiates(X,Y) ).
tv(avoid,avoids, avoided,
   avoided, avoiding, X^Y^ ' avoids(X,Y) ).
tv(output,outputs, output,

```

```

    output, outputting, X^Y^ \ outputs(X,Y) ).
tv(despise, despises, despised,
    despised, despising, X^Y^ \ despises(X,Y) ).

/* ***** */
/* Empty words */
/* ***** */

detlessn(A,D) :-
    n(A,D).

n( [],          X^ \person(X)          ).

n(A,D) :-
    inter(A,B,C),
    final(B,C,D).

inter(A,B,C) :-
    functor(B,A,1),
    arg(1,B,C).

final(B,C,D) :-
    prefix(B,C,D).

prefix(B,C,C^ \B).

adj(A,D) :-
    n(A,D).

tv(nomatch,nomatch,nomatch,nomatch,A,E) :-
    step1(A,B,C,D),
    step2(B,C,D,E).

step1(A,B,C,D) :-
    functor(B,A,2),
    arg(1,B,C),
    arg(2,B,D).

step2(B,C,D,E) :-
    step3(B,C,D,E).

step3(B,C,D,C^D^ \B).

/* ***** */
/* conc(List1,List2,List3). */
/* Concatenate a list. */
/* e.g. conc([dulce,et],[decorum,est],L). */
/* L=[dulce,et,decorum,est]. */
/* ***** */

conc([], List, List).

conc([Element|Rest], List, [Element|LongRest]) :-
    conc(Rest, List, LongRest).

/* ***** */
/* read_sent(Words). */
/* Words is set of words from the input delimited by spaces and */

```



```

/* ended by a newline. */
/* Spaces are ignored. */
/* Everything else starts a word so get the word, pack the chars. */
/* into an atom and get some more words. */

read_sent(Words) :-
    get0(Char),
    read_sent(Char, Words).

read_sent(C, []) :- newline(C),
    !.

read_sent(C, Words) :-
    space(C),
    !,
    get0(Char),
    read_sent(Char, Words).

/* Exit if input is ~ */

read_sent(C, Words) :- tilda(C),
    telling(Old),
    tell(lastsubsum),
    listing(subsumes),
    told,
    halt.

read_sent(Char, [Word|Words]) :-
    read_word(Char, Chars, Next),
    name(Word, Chars),
    read_sent(Next, Words).

/* ***** */
/* read_word(Chars). */
/* Chars is the list of input characters delimited by */
/* spaces or newlines. */
/* A space ends a word. */
/* A newline ends a word. */
/* All other characters are added to the list. */

read_word(C, [], C) :- space(C),
    !.

read_word(C, [], C) :- newline(C),
    !.

read_word(Char, [Char|Chars], Last) :-
    get0(Next),
    read_word(Next, Chars, Last).

/* ***** */
/* space(Char). */
/* Char is the ASCII code for the space character. */

space(32).

/* ***** */

```

```

/* newline(Char).                                     */
/* Char is the ASCII code for the newline char.      */

newline(10).

/*****
/* Code for ~.                                         */

tilda(126).

/*****
/* getsubclasses(X,Y)                                 */
/* e.g. getsubclasses(top,M).                         */
/*      M=[abstract,animate,concrete,mental]         */

getsubclasses(X,V):-
    setof(W,subsumes(X,W),V).

getsubclasses(X,V):-
    nl.

/*****
/* askwhichsubclass(X,Y)                             */
/* e.g. askwhichsubclass(tractor,[substance,machine]). */
/*      Is tractor one of these or something else:   */
/*      [substance,machine]?                         */

askwhichsubclass(X,Y):-
    nl,
    write('Is '),
    write(X),
    write(' one of these or something else: '),
    nl,
    write(Y),
    write('?').

/*****
/* assertsubsumption(X)                             */
/* e.g. assertsubsumption(subsumes(concrete,machine)). */
/*      Have added subsumes(concrete,machine) to the */
/*      dictionary.                                   */

assertsubsumption(Ass):-
    assert(Ass),
    nl,
    write('Have added '),
    write(Ass),
    write(' to the dictionary.').

/*****
/* askforrefinement(X,Y)                             */
/* e.g. askforrefinement(animate,[human,animal]).    */
/*      What sort of animate do you mean:           */
/*      [human,animal]?                             */

askforrefinement(X,Y):-
    nl,

```

```

write('What sort of '),
write(X),
write(' do you mean: '),
nl,
write(Y),
write('?').

/*****/
/* askwhethersubsume(F,G) */
/* e.g. askwhethersubsume(machine,tractor). */
/* Please type machine subsumes tractor if you */
/* want to extend the dictionary. */

askwhethersubsume(F,G):-
    nl,
    write('Please type '),
    nl,
    write(' '),
    write(F),
    write(' subsumes '),
    write(G),
    nl,
    write('if you want to extend the dictionary.').

/*****/
/* getsubclassesandaskforrefine(X) */
/* e.g. getsubclassesandaskforrefine(animate). */
/* What sort of animate do you mean: */
/* [human,animal]? */

getsubclassesandaskforrefine(W):-
    subsumes(W,B),
    getsubclasses(W,V),
    askforrefinement(W,V).

getsubclassesandaskforrefine(W):-
    getexquestion(W),
    nl.

getsubclassesandaskforrefine(W):-
    nl.

/*****/
/* getsubclassesandaskwhich(C,P) */
/* e.g. getsubclassesandaskwhich(top,fish). */
/* Is fish one of these or something else: */
/* [abstract,animate,concrete,mental]. */

getsubclassesandaskwhich(C,P):-
    subsumes(C,B),
    getsubclasses(C,S),
    askwhichsubclass(P,S).

getsubclassesandaskwhich(C,P):-
    getexquestion(C),
    nl.

```

```
getsubclassesandaskwhich(C,P):-
    nl.
```

```
/* ***** */
/* getexquestion(X) */
/* Further semantic analysis is impossible; invoke */
/* other kinds of inferencing strategies. */
```

```
getexquestion(C):-
    nl,
    write('External questions absent.').
```

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